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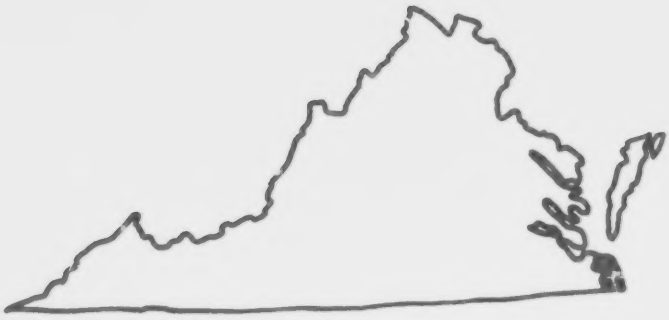
FLOOD INSURANCE STUDY

CITY OF VIRGINIA BEACH, VIRGINIA
INDEPENDENT CITY



REVISED:
DECEMBER 5, 1990

Federal Emergency Management Agency

COMMUNITY NUMBER - 515531

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program (NFIP) have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision (LOMR) process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current FIS components.

Initial Flood Insurance Study Effective Date: April 23, 1971

Flood Insurance Study Revised: July 1, 1974
October 8, 1976
July 17, 1984 (Flood Insurance Rate Map effective January 17, 1985)
December 5, 1990

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Pine Tree Branch	Panel 09P
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Exhibit 2 - Flood Boundary and Floodway Map Index
Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map Index
Flood Insurance Rate Map

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Virginia Beach, Virginia, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and assist the community in their efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the state (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The original hydrologic and hydraulic analyses were prepared by the Norfolk District of the U. S. Army Corps of Engineers (COE), for the Federal Emergency Management Agency (FEMA), under Inter-Agency Agreement No. EMW-E-0105, Project Order No. 10. This work was completed in February 1983.

In this revision, updated topographic information for the Stumpy Lake watershed was submitted by the City of Virginia Beach, under agreement with FEMA. The work for this revision was completed in December 1989. Updated topographic information for the Charlestowne Lakes South Area was also included in this revision. That work was prepared by the City of Virginia Beach and was completed in December 1988.

1.3 Coordination

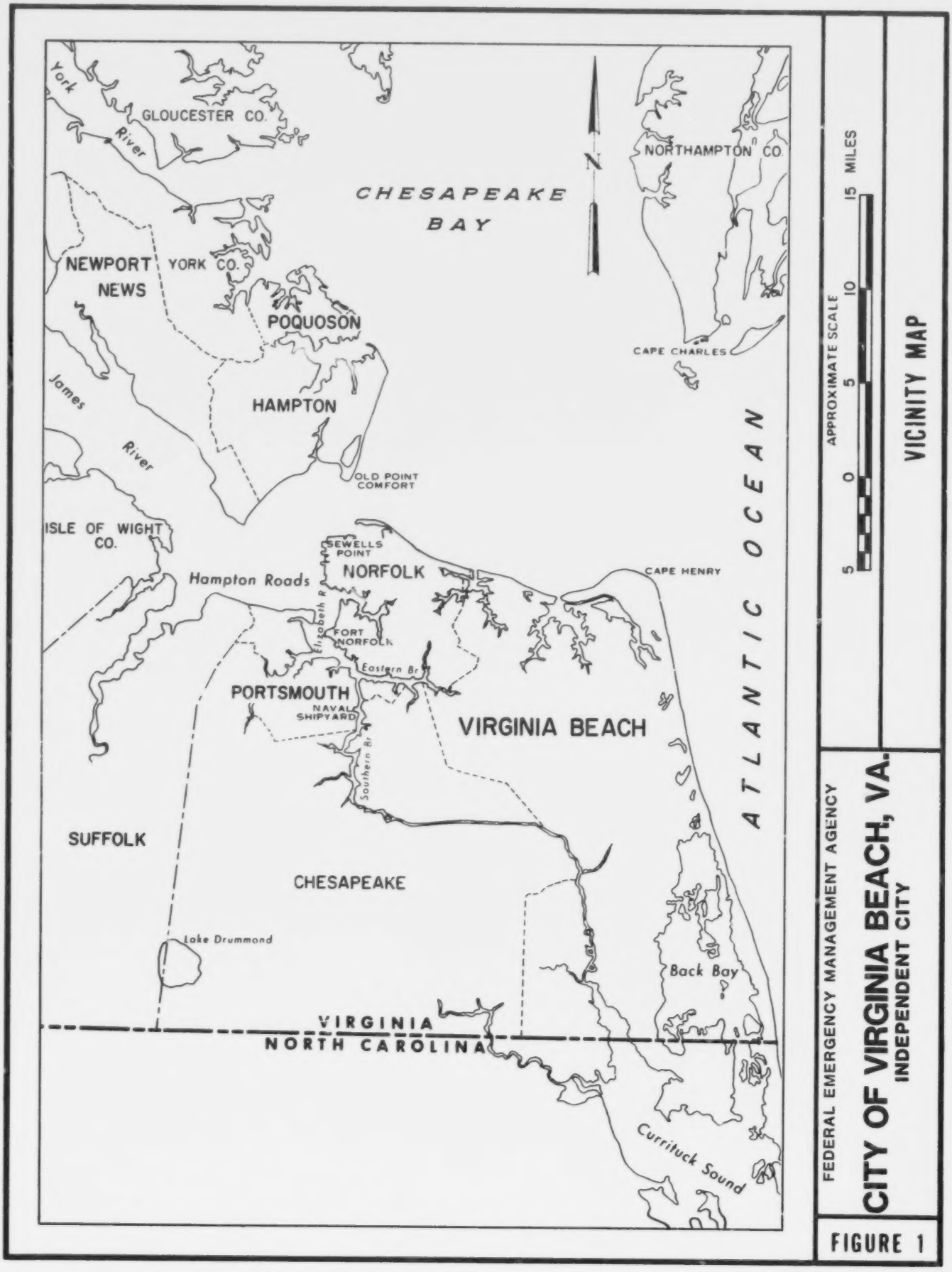
On May 12, 1980, an initial Consultation and Coordination Officer's (CCO) meeting was held with representatives from FEMA, the city, the Virginia State Water Control Board, and the COE (the study contractor) to explain the nature and purpose of the study and the scope and limits of the work, and to obtain flood information concerning the community. A search for basic data was made at all levels of government. On February 3, 1984, the results of the study were reviewed at a final CCO meeting with representatives from FEMA, the city, and the study contractor.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the City of Virginia Beach, Virginia. The Little Creek Amphibious Base, Fort Story Military Reservation, Seashore State Park, Oceana Naval Air Station, Camp Pendleton State Military Reservation, Back Bay National Wildlife Refuge, False Cape State Park, Barbours Hill Wildlife Management Area, Mackay Island National Wildlife Refuge, and several other unnamed military reservations were not included in this study. The area of study is shown on the Vicinity Map (Figure 1).

All or portions of the following flooding sources were studied by detailed riverine methods: Lake Smith Tributary from its confluence with Lake Smith to a point approximately 1.42 miles upstream; Lake Pembroke from its confluence with the Western Branch Lynnhaven River to a point approximately 1.28 miles upstream; Thalia Creek from its confluence with the Western Branch Lynnhaven River to a point approximately 1.61 miles upstream of the Norfolk Southern Railroad bridge crossing; Left Bank Tributary Thalia Creek from its confluence with Thalia Creek to the downstream face of Windsor Oaks Boulevard; Holland Road Tributary Thalia Creek from its confluence with Left Bank Tributary Thalia Creek to a point approximately 300 feet upstream of Timberlake Drive; Kings Point System from the confluence with the Western Branch Lynnhaven River to a point approximately 1.55 miles upstream; Pine Tree Branch from its confluence with the Eastern Branch Lynnhaven River to a point approximately 0.91 mile upstream; Canal No. 2-London Bridge Creek from Virginia Beach Boulevard to Lynnhaven Parkway; Canal No. 2-West Neck Creek from its confluence with the North Landing River to Lynnhaven Parkway; Holland Road Corridor System from the confluence with Green Run Canal to a point approximately 1.89 miles upstream; Green Run Canal from its confluence with Canal No. 2-West Neck Creek to a point approximately 1.86 miles upstream; Mill Dam Creek from its confluence with Broad Bay to Old Donation Parkway; Canal No. 1 North from its confluence with Linkhorn Bay to a point approximately 1.69 miles above the Virginia Beach Toll Road; Fox Run Canal from its confluence with the Eastern Branch Elizabeth River to Brandywine Drive; Lake Banbury from its confluence with the Eastern Branch Elizabeth River to a point approximately 1.42 miles upstream; Cedar Hill Canal from its confluence with the Eastern Branch Elizabeth River to Centreville Turnpike; Salem Canal from its confluence with the North Landing River to Providence Road; Canal Number 4 from its confluence with Salem Canal to a point approximately 2.69 miles upstream; and Colony Acres Canal from its confluence with Canal No. 2-West Neck Creek to a point approximately 1.41 miles upstream.


York River
GLOUCESTER CO.
CHESAPEAKE BAY
NORTHAMPTON CO.
NEWPORT NEWS
YORK CO.
POQUOSON
CAPE CHARLES
James River
HAMPTON
OLD POINT COMFORT
ISLE OF WIGHT CO.
SEWELLS POINT
NORFOLK
Hampton Roads
CAPE HENRY
Elizabeth R.
FORT NORFOLK
Eastern Br.
PORTSMOUTH
NAVAL SHIPYARD
VIRGINIA BEACH
Southern Br.
SUFFOLK
CHESAPEAKE
Lake Drummond
Back Bay
VIRGINIA
NORTH CAROLINA
Currituck Sound
ATLANTIC OCEAN
N
APPROXIMATE SCALE
5 0 5 10 15 MILES
VICINITY MAP
FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF VIRGINIA BEACH, VA.
INDEPENDENT CITY
FIGURE 1

Tidal flooding from the Atlantic Ocean, Chesapeake Bay, the Elizabeth River, Lake Smith, Lynnhaven Bay, the Lynnhaven River, Broad Bay, Linkhorn Bay, Rudee Inlet, Lake Holly, Back Bay, Chubb Lake, Bradford Lake, and Lake Taylor was also studied by detailed methods. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction.

All or portions of the following flooding sources were studied by approximate methods: Pleasure House Lake, Lake Edward, the Western Branch Lynnhaven River, the Eastern Branch Lynnhaven River, the Eastern Branch Elizabeth River, Thalia Creek, Canal No. 1 North, Whispering Waterway, Wolfsnare Creek, Holland Road Tributary Thalia Creek, Lake Christopher, Stumpy Lake, Lake Placid, and several small areas with unknown sources. The first revision incorporated updated topographic information and floodplain boundaries for an area of approximate study known as Charlestowne Lakes South, located immediately west of Stumpy Lake. This revision incorporates updated topographic information and floodplain boundaries for an area of approximate study known as the Stumpy Lake watershed Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and the City of Virginia Beach.

2.2 Community Description

The City of Virginia Beach is located in the southeastern corner of Virginia. It is bordered by the Atlantic Ocean to the east, Chesapeake Bay to the north, the Cities of Norfolk and Chesapeake to the west, and the unincorporated areas of Currituck County, North Carolina to the south. The 1980 population of Virginia Beach was estimated to be 260,860 (Reference 1).

The city has a total land area of 258.7 square miles. Within the city are thousands of acres of farmland, five military installations, 28 miles of oceanfront, 10 miles of bayfront, and 51.3 square miles of inland water. Agriculture, federal installations, and tourism are the mainstays of the city's economy.

Princess Anne County, which was named for the daughter of James II who later became Queen Anne, was formed in 1691 from lower Norfolk County. Although the first English settlers in the New World landed at Cape Henry in 1607, they later sailed up the James River to form the Jamestown Colony. The first settlement in what is now Virginia Beach was established in 1621, on Lynnhaven Bay. In 1822, the county seat of Princess Anne County was moved from Kempsville to Princess Anne, which is the present site of the Municipal Center Complex of Virginia Beach (Reference 2).

Virginia Beach was incorporated as a town in 1906, and in 1952 became an independent city. In 1963, the city was greatly enlarged by a merger with Princess Anne County.

An arm of the Eastern Branch Elizabeth River enters the city from the west. In the southern part of the city are the broad expanses of Back Bay and Broad Bay. Important inland waterways include Rudee Inlet and Lake Holly, tidal inlets of the Atlantic Ocean, and Lynnhaven Bay, Broad Bay, Linkhorn Bay, and Little Creek, which are tidal estuaries of the Chesapeake Bay. Lake Smith and Stumpy Lake are sizable landlocked bodies of water within the city.

The flood plains in Virginia Beach abound with commercial, industrial, and residential development and public utilities. Most of the development in Virginia Beach has taken place in the northern half of the city. The southern half remains essentially rural with farming the principal occupation. There is some manufacturing within the city, but most of the residents find employment in manufacturing industries in surrounding cities or in the federal installations. In addition, many people are engaged in the tourist industry. Virginia Beach is experiencing the fastest growth of any city on the Atlantic Seaboard. Many hotels and motels have been built in recent years.

Virginia Beach is situated in the Coastal Plain province and is underlaid primarily by unconsolidated sand and clay strata. The terrain is essentially flat with ground elevations averaging approximately 12 feet. Small areas, mostly in the form of dunes, rise above 15 feet. Shallow waters of less than 20 feet fringe the coastal shoreline, and depths in the inland bays and connecting waters are generally less than 10 feet.

The city enjoys a temperate climate with moderate seasonal changes. The climate is characterized by moderately warm summers with temperatures averaging approximately 78 degrees Fahrenheit (°F) in July, the warmest month. The winters are cool with temperatures averaging approximately 41°F in January, the coolest month. The average annual precipitation is approximately 45 inches. There is some variation in the monthly averages; however, rainfall is distributed evenly throughout the year. Snowfall is infrequent, generally occurring in light amounts which normally melt within 24 hours (Reference 2).

2.3 Principal Flood Problems

The coastal areas of Virginia Beach are vulnerable to tidal flooding from major storms commonly referred to as hurricanes and northeasters. Both types of storms produce winds which push large volumes of water against the shore.

Hurricanes, with their high winds and heavy rainfall, are the most severe storms that hit the area. The term "hurricane" is applied to an intense cyclonic storm originating in tropical or subtropical latitudes in the Atlantic Ocean just north of the equator. A study of tracks of all

tropical storms for which there is a record indicates that, on an average of once a year, a tropical storm of hurricane force passes within 250 miles of the area and poses a threat to Virginia Beach. While hurricanes can affect the area from May through November, nearly 80 percent occur in the months of August, September, and October, with approximately 40 percent occurring in September. The most severe hurricane to strike the area occurred in August 1933. Other notable hurricanes which caused significant flooding in Virginia were those of September 1933, September 1936, and September 1960 (Reference 3).

Another type of storm which could cause severe damage to the study area is the northeaster. This is also a cyclonic-type storm and originates with little or no warning along the middle and northern Atlantic coast. Northeasters occur most frequently in the winter but can occur at any time. Accompanying winds are not of hurricane force but are persistent, causing above-normal tides for long periods of time. The March 1962 northeaster was the worst to hit the study area. Other northeasters which caused significant flooding in Virginia Beach included those of March 1927, October 1948, and April 1956 (Reference 3).

The depth of flooding during these storms depends on the velocity, direction, and duration of the wind, the size and depth of the body of water over which the wind is acting, and the astronomical tide. For instance, strong and persistent northerly and easterly winds will cause flooding of the shorelines of the Chesapeake Bay, the Atlantic Ocean, and their connecting inland waterways. Flooding in the Back Bay and North Landing River areas is caused by strong winds from a southerly direction. As would be expected, because of the larger size of the waterbodies involved, flooding along the shorelines of the Chesapeake Bay, the Atlantic Ocean, and the Elizabeth River occurs to a greater depth than flooding in the southern portion of the city. Simultaneous flooding of both the outer coastal areas and southern bay areas of the city is not possible except in rare events where the surge-producing forces cause either the destruction or overtopping of the barrier dunes which separates the Atlantic Ocean from the inland waters in the southern portion of the city. The duration of flooding depends on the duration of the tide-producing forces. Floods caused by a hurricane are usually of much shorter duration than the ones caused by a northeaster. Flooding from hurricanes rarely lasts more than one tidal cycle, whereas flooding caused by northeasters can last several days, during which the most severe flooding takes place at the time of the peak astronomical tide.

The timing or coincidence of the maximum storm surge with the normal high tide is an important factor in the consideration of flooding from tidal sources. Tidal waters in the study area normally fluctuate twice daily from an elevation of 1.7 feet to -1.7 feet in the Atlantic Ocean and from

1.4 feet to -1.4 feet in the Chesapeake Bay and the Elizabeth River. The range of fluctuation is somewhat less in most of the connecting interior waterways. There are no measurable astronomical tides in Back Bay or the North Landing River.

The study area also contains numerous estuaries of the Atlantic Ocean and the Chesapeake Bay which are subject to tidal flooding in their lower reaches. Flooding in the upper reaches of these streams can be caused by heavy general rains occurring anytime throughout the year. Flooding can also occur as a result of intense rainfall produced by local summer thunderstorms or tropical disturbances such as hurricanes which move into the area from the Gulf of Mexico or Atlantic coast. Flood heights on these streams can rise from normal to extreme flood peaks in a relatively short period of time. The duration of flooding depends on the duration of runoff-producing rainfall. In some cases, floods may last for a couple of days, whereas floods occurring as a result of short duration summer thunderstorms usually rise to a maximum peak stage and subside to near normal levels in less than a day.

All development in the flood plains is subject to water damage. Additionally, some areas, depending on exposure, are subject to high velocity wave action which can cause structural damage and severe erosion along beaches. Waves are generated by the action of wind on the surface of the water. The entire Virginia Beach shoreline is vulnerable to wave damage because of the vast exposure afforded by the Chesapeake Bay and the Atlantic Ocean.

Virginia Beach has experienced major storms since the early settlement of the area. Historic accounts of severe storms in the area date back several hundred years. The following paragraphs discuss some of the larger known floods which have occurred in recent history. This information is based on newspaper accounts, historic records, field investigations, and routine data collection programs normally carried out by the Norfolk District of the COE.

The earliest known storm of record causing extensive damage in the Virginia Beach area occurred on March 2-3, 1927. Practically all damage inflicted on the city resulted from the high tide of Wednesday night, March 2. This storm undermined or flanked most of the protective structures in existence and severely damaged or destroyed the majority of them. The beaches were almost completely denuded of the overlying sand. All along the beach, the sea washed the sand away, leaving the clay undersoil exposed. The greatest damage was in the vicinity of the main resort area where a large hotel and many other structures were severely damaged. Figures 2, 3, 4, and 5 show conditions of the beach and damage resulting from the March 1927 storm.

Figure 2 - View looking north from 7th Street following March 1927 storm. Note denuded condition of the beach.

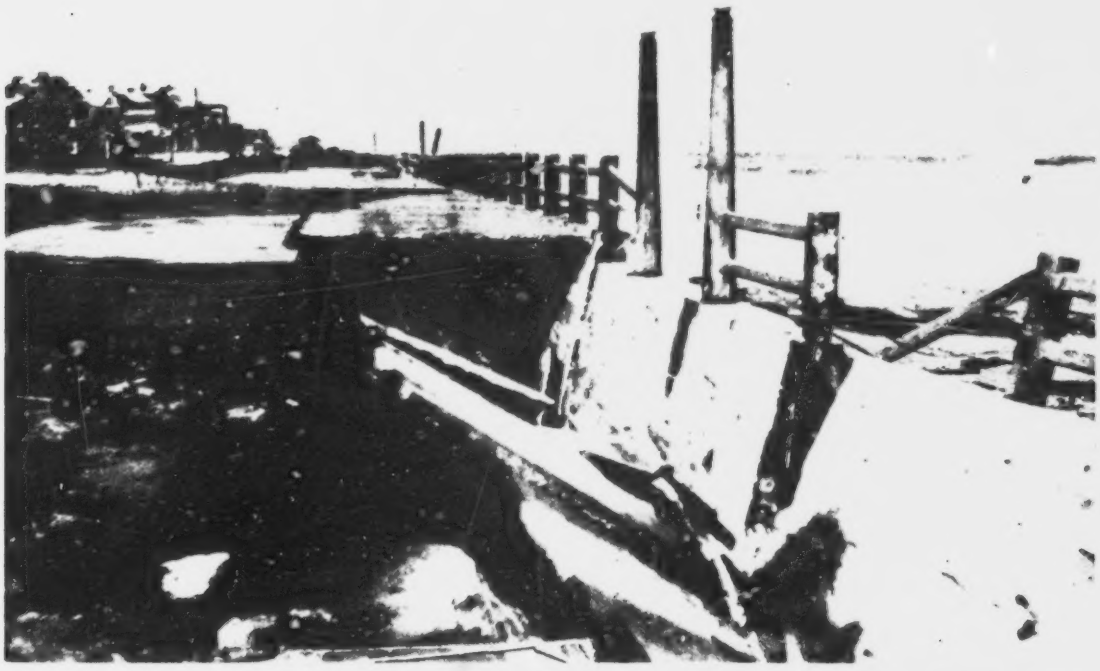


Figure 3 - View showing undermined concrete gravity-type wall between 9th and 11th Streets following March 1927 storm.

Figure 4 - View of damage in the vicinity of 15th Street following the March 1927 storm.

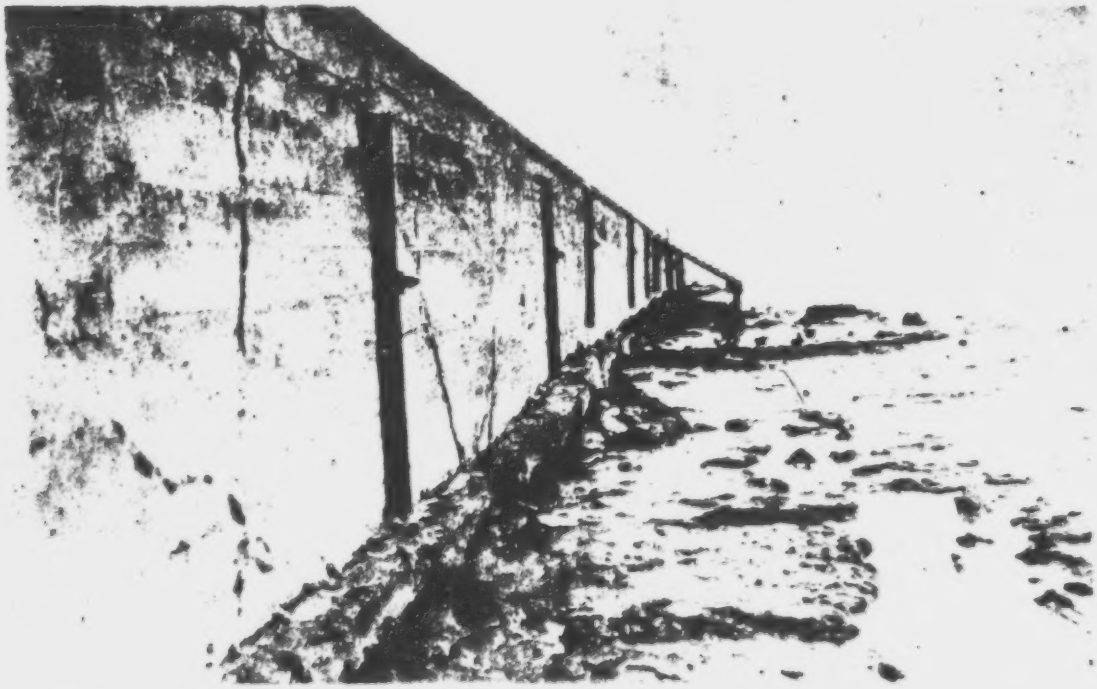


Figure 5 - View of damage in the vicinity of 32nd Street following the March 1927 storm. The wall was seriously undermined, and considerable fill was lost from behind the wall. Note the denuded condition of the beach and the complete absence of sand.

The eye of the August 1933 hurricane passed directly over Virginia Beach and caused the most extensive flooding in the city in the past 200 years or more. In most parts of the city, the maximum storm surge was the greatest of record and occurred approximately 3 hours before, but persisted through, the peak of the astronomical tide. Estimates of or observed maximum tidal elevations were 8.6 for the Atlantic coast and Lynnhaven Bay, 8 feet for the Eastern Branch Elizabeth River, approximately 5.3 feet for Broad Bay and Linkhorn Bay, and approximately 3.8 feet in the Back Bay and North Landing River areas. Extensive damage to waterfront property and low-lying buildings occurred during this storm. High waves caused much of the structural damage in exposed areas along the open coast. In addition to damage from tidal flooding, much damage was caused to roofs, communication lines, and other structures by the high winds.

A northeaster struck the Virginia coastline on October 4, 1948, and continued for several days. It reached maximum intensity on October 5 with tide elevations reaching 5.1 feet in nearby Norfolk. Wind velocities at Cape Henry varied from 30 to 45 miles per hour with gusts up to 60 miles per hour. The boardwalk was severely buffeted for its entire length; the greatest damage was sustained between 17th Street and 7th Street. This storm also moved considerable sand from the beach, creating conditions quite similar to those caused by the March 1927 storm. Figures 6 through 9 show damage caused by the October 4-5, 1948, northeaster.

Figure 6 - View of the failure of the boardwalk near 11th street following the October 1948 northeaster.

Figure 7 - Loss of fill behind the boardwalk at the same location as Figure 6 (October 1948 storm).

Figure 8 - View of 14th Street following October 1948 storm. Note water flowing under face of boardwalk.

Figure 9 - View showing heavy loss of fill behind the boardwalk at 14th Street following October 1948 storm.

The fourth highest flood of recent years occurred on April 11, 1956, as a result of another northeaster. It produced a steady northeast wind in the Virginia Beach area for approximately 30 hours. The tides were approximately 4 feet above normal for 12 hours and produced the maximum tidal crest on the morning of the 11th. Damage to structures was light; however, a considerable amount of sand was eroded from the beaches.

The most recent tidal stage of major proportions occurred during the northeaster of March 6-8, 1962. Disastrous flooding and high waves occurred all along the Atlantic Seaboard from New York to Florida. This flood was unusual even for a northeaster since it was caused by a low pressure cell which moved south to north past Virginia Beach and then reversed its course moving again to the south. Huge volumes of water and high waves battered the mid-Atlantic coastline for several days.

The maximum flood height at Virginia Beach occurred on the morning of March 7 and reached approximately 6.7 feet on the Atlantic coast. Extensive flooding and much damage resulted along the Atlantic Ocean, the Chesapeake Bay, and their connecting waterways. The hardest hit sections of the city were Sandbridge Beach, the area from Rudee Inlet to 49th Street, North Virginia Beach above 57th Street, and Ocean Park on the Chesapeake Bay. Tide heights reached during this storm were the second highest of record in the area, but were almost 2 feet lower than those

reached in the August 1933 hurricane. The damaging effect, however, was the greatest of any storm in the area due to the increased development along the shoreline since 1933. Another contributing factor was that tides during this storm remained above normal for four days. High waves added to the structural damage caused by the high water. Severe eroding of the beaches and shorefront also occurred. The seawall fronting the main resort area in the city was seriously damaged. Estimates of damage in Virginia Beach were more than 8 million dollars. These water levels are indicative of stages experienced in the eastern and northern sections of the city. Stages on Back Bay and the North Landing River tend to be lowered by northeast winds and thus were inconsequential during the 1962 storm.

Figures 10 through 16 show damage caused by the March 1962 northeaster.

Figure 10 - Destruction of the boardwalk north of 22nd Street to 23rd Street following March 1962 northeaster.

Figure 11 - Washout at 35th Street and north end of the boardwalk following March 1962 northeaster.

Figure 12 - Destruction of bulkhead at 36th Street, looking north (March 1962 northeaster).

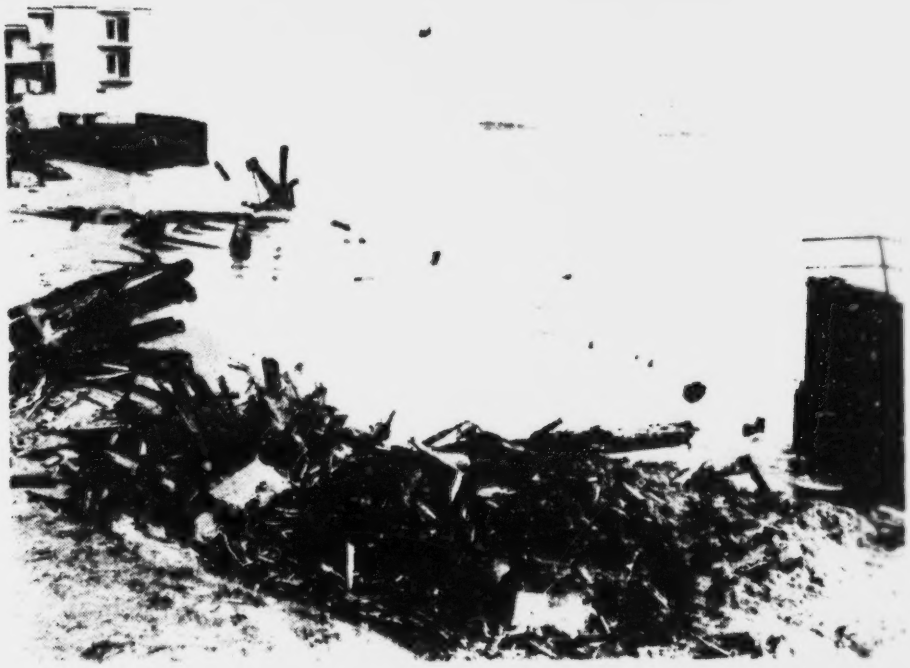


Figure 13 - View looking north between 39th Street and 40th Street March 1962 northeaster).

Figure 14 - View looking north between 43rd Street and 45th Street (March 1962 northeaster).

Figure 15 - End of wooden bulkhead at 46th Street, looking north (March 1962 northeaster).

2.4 Flood Protection Measures

There are no existing flood control structures that would provide protection during major floods in the study area. However, there are a number of measures that have afforded some protection against minor flooding. These include a concrete bulkhead and promenade, stone, steel and wooden bulkheads, sand dunes, and non-structural measures for flood plain management such as zoning and building codes.

The concrete bulkhead and promenade was constructed by local interests in 1927. It extends from 7th Street to 35th Street and consists essentially of a vertical-faced wall and a concrete deck which is approximately 20 feet wide at an elevation of 11.4 feet. At various times during the period 1938 to 1952, the structure suffered severe storm damage. In 1953 and 1954, the wall was restored by the Virginia Beach Erosion Commission. During the March 1962 storm, the wall was again severely damaged, and emergency repairs were made by the COE.

Wood and steel bulkheads, which were also constructed by local interests, extend from 35th Street to 49th Street. Light wooden bulkheads have been built along portions of the Chesapeake Bay, but have proven ineffective as flood protection measures.

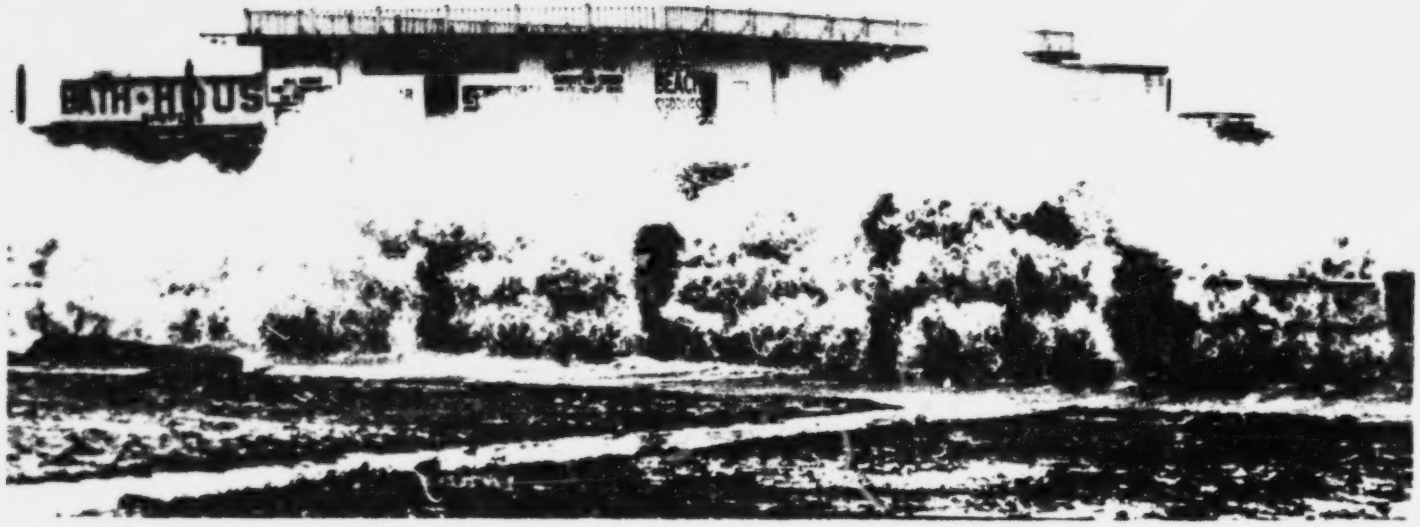


Figure 16 - Waves breaking on the boardwalk at the fishing pier at 15th Street (March 1962 northeaster).

Within the 28 miles of ocean shoreline, there are approximately 20 miles of sand dunes which vary in height from 12 feet to 25 feet. These dunes afford considerable protection to adjoining property.

The city has passed ordinances as required by FEMA to qualify for the regular program of flood insurance. These measures are found in Article 12 of the city's Comprehensive Zoning Ordinance - Flood Plain Regulations. These requirements, along with others such as Article 16, the Coastal Primary Sand Dune Zoning Ordinance, have been beneficial in reducing the chance of future flood damage in the community.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each riverine flooding source studied in detail affecting the community.

For the streams studied in detail, it was necessary to develop flood frequencies by synthetic means since there are no records of streamflow on these streams and no available high-water data to permit development of flood-stage frequency relationships. The lack of adequate streamflow records required an analysis of rainfall and runoff characteristics of the watersheds in determining frequency estimates. These analyses involved the application of rainfall-runoff amounts to a synthetic graph

(unit hydrograph). Based on hydraulic parameters (slope, length, drainage area, "n" values, and time of concentration) determined for the streams, unit graphs were developed for several locations on each stream using the Clark Method. Rainfall-frequency values selected from Technical Paper No. 40 were then applied to the unit graphs to obtain the desired discharge frequencies (Reference 4).

A summary of drainage area-peak discharge relationships for the streams studied by detailed methods is shown in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
LAKE SMITH TRIBUTARY					
At its confluence with Lake Smith	1.8	340	520	610	820
LAKE PEMBROKE					
Upstream side of Independence Boulevard	1.6	1,050	1,440	1,640	2,160
Downstream side of Independence Boulevard	1.6	550	780	900	1,190
THALIA CREEK					
At the Norfolk Southern Railroad crossing	5.7	900	1,220	1,290	1,490
LEFT BANK TRIBUTARY THALIA CREEK					
At its confluence with Thalia Creek	2.5	990	1,430	1,650	2,230
HOLLAND ROAD TRIBUTARY THALIA CREEK					
At its confluence with Left Bank Tributary Thalia Creek	1.3	640	910	1,050	1,420
KINGS POINT SYSTEM					
At the Johnson Street bridge	0.7	92	148	173	223

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TABLE 1 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
PINE TREE BRANCH					
At its confluence with the Eastern Branch Lynnhaven River	0.9	170	200	230	320
CANAL NO. 2-LONDON BRIDGE CREEK					
At Virginia Beach Boulevard	6.5	1,740	2,640	3,040	4,100
CANAL NO. 2-WEST NECK CREEK					
At Indian River Road	16.6	3,130	4,700	5,600	7,560
HOLLAND ROAD CORRIDOR SYSTEM					
At its confluence with Green Run Canal	1.4	230	340	390	530
GREEN RUN CANAL					
At its confluence with Canal No. 2-West Neck Creek	1.5	340	480	570	760
MILL DAM CREEK					
At a point approximately 2,500 feet downstream of Mill Dam Road	1.1	510	740	850	1,150
CANAL NO. 1 NORTH					
At Virginia Beach Boulevard	3.5	230	300	330	390
At a point approximately 850 feet upstream of Norfolk Southern Railroad	0.9	360	520	610	820
FOX RUN CANAL					
At Lord Dunsmore Drive	1.5	620	890	1,030	1,390
At Brandywine Drive	0.5	320	460	530	720
LAKE BANBURY					
At its confluence with the Eastern Branch Elizabeth River	1.2	750	1,060	1,210	1,640
At Indian River Road	0.5	470	660	750	1,010

TABLE 1 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
CEDAR HILL CANAL					
At its confluence with the Eastern Branch Elizabeth River	3.2	170	270	330	470
SALEM CANAL					
At the confluence of Canal No. 4	5.0	1,270	1,850	2,140	2,890
At Recreation Drive	1.4	370	530	620	840
CANAL NO. 4					
At its confluence with Salem Canal	5.9	1,420	2,080	2,420	3,260
COLONY ACRES CANAL					
At its confluence with Canal No. 2-West Neck Creek	5.7	950	1,400	1,630	2,200

Analyses were also carried out to establish the peak elevation-frequency relationships for the tidal flooding sources studied in detail affecting the community.

Tide records at Virginia Beach are inadequate to establish a tide-frequency relationship. Records of tide elevations are available for intermittent or short periods at a number of locations in and near the city. The adopted tide frequency was obtained by a correlation of the tide frequency curve developed for Norfolk Harbor, located approximately 10 miles inside the Chesapeake Bay, with available tide records and high-water marks at Virginia Beach. The frequency curve for Norfolk Harbor was developed using a Pearson Type III analysis without logs for the selected point of record from 1928 through 1978. The data were stage-related to Virginia Beach using high-water marks.

The stillwater elevation is the elevation of the water due solely to the effects of the astronomical tides, storm surge, and wave setup on the water surface. The inclusion of wave heights, which is the distance from the trough to the crest of the wave, increases the water-surface elevations. The height of a wave is dependent upon wind speed and its duration, depth of water, and length of fetch. The wave crest elevation is the sum of the stillwater elevation and the portion of the wave height above the stillwater elevation.

Wave heights and corresponding wave crest elevations were determined using the National Academy of Sciences (NAS) methodology (Reference 5). The stillwater elevations and the maximum wave crest elevations of the selected recurrence intervals are shown in Table 2, "Summary of Stillwater Elevations."

TABLE 2 - SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet) 10-YEAR[1]	50-YEAR[1]	100-YEAR	500-YEAR[1]
CHESAPEAKE BAY				
Entire shoreline	6.5	8.1	8.7/13[2]	10.1
ATLANTIC OCEAN				
Entire shoreline	6.5	8.1	8.7/13[2]	10.1
EASTERN BRANCH ELIZABETH RIVER				
Entire shoreline	6.4	7.8	8.5/9[2]	9.8
LAKE SMITH				
Entire shoreline	5.5	7.0	8.0[1]	9.0
LYNNHAVEN BAY				
Entire shoreline	5.9	7.2	7.8[1]	9.2
LYNNHAVEN RIVER				
Entire shoreline	5.9	7.2	7.8[1]	9.2
BROAD BAY				
Entire shoreline	5.3	6.4	6.9[1]	8.1
LINKHORN BAY				
Entire shoreline	5.3	6.4	6.9[1]	8.1
RUDEE INLET				
Entire shoreline	6.5	8.1	8.7[1]	10.1
LAKE HOLLY				
South of Southern Boulevard	5.5	7.0	8.0[1]	10.1
North of Southern Boulevard	4.5	6.0	7.0[1]	8.0

[1]Stillwater Elevation
[2]Stillwater/Maximum Wave Crest Elevation

TABLE 2 - SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet) 10-YEAR[1]	50-YEAR[1]	100-YEAR[1]	500-YEAR[1]
BACK BAY				
Entire shoreline	3.3	4.5	5.0	6.5
CHUBB LAKE				
Entire shoreline	5.5	7.0	8.0	9.0
BRADFORD LAKE				
Entire shoreline	5.5	7.0	8.0	9.0
LAKE TAYLOR				
Entire shoreline	6.4	7.8	8.5[1]	9.8

[1]Stillwater Elevation

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

Cross sections and bridge data used in the backwater computations for the riverine flooding sources were obtained from field surveys, as built subdivision plans, Virginia Department of Highways drawings, and topographic maps (Reference 6). All bridges and culverts were field surveyed to obtain elevation data and structural geometry.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

Water-surface elevations of floods of the selected recurrence intervals were computed using the COE HEC-2 step-backwater computer program (Reference 7). Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals. Starting water-surface elevations were calculated by the slope/area method.

Channel roughness factors (Manning's "n") used in the hydraulic computations were determined on the basis of field inspection of the streams and flood plain areas. The channel "n" values for the riverine flooding sources ranged from 0.025 to 0.045, and the overbank "n" values ranged from 0.045 to 0.100.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Hydraulic analyses, considering storm characteristics and the shoreline and bathymetric characteristics of the tidal flooding sources studied, were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along these shorelines.

Special consideration was given to the vulnerability of Virginia Beach to wave attack. During severe storms such as the March 1962 northeaster and the August 1933 hurricane, wave attack caused breaching and failure of bulkheads and dunes. The intruding waters caused structural damage to buildings behind the bulkheads and dunes. Much of the damage can be attributed to the collapse of structures on undermined footings.

Areas of coastline subject to significant wave attack are referred to as coastal high hazard zones. The COE has established the 3-foot breaking wave as the criterion for identifying the limit of coastal high hazard zones (Reference 8). The 3-foot wave has been determined as the minimum size wave capable of causing major damage to conventional wood frame or brick veneer structures. This criterion has been adopted by the FEMA for the determination of V-zones.

The methodology for analyzing wave heights and corresponding wave crest elevations was developed by the NAS (Reference 5). The NAS methodology is based on three major concepts.

First, a storm surge on the open coast is accompanied by waves. The maximum height of these waves is related to the depth of water by the following equation:

$$H_b = 0.78d$$

where H_b is the crest to trough height of the maximum or breaking wave and d is the stillwater depth. The elevation of the crest of an unimpeded wave is determined using the equation:

$$Z_w = S_* + 0.7H_* = S_* + 0.55d$$

where Z_w is the wave crest elevation, S_* is the stillwater elevation at the site, and H_* is the wave height at the site. The 0.7 coefficient is the portion of the wave height which reaches above the stillwater elevation. H_b is the upper limit for H_*.

The second major concept is that the breaking wave height may be diminished by dissipation of energy by natural or man-made obstructions. The wave height transmitted past a given obstruction is determined by the following equation:

$$H_t = BH_i$$

where H_t is the transmitted wave height, H_i is the incident wave height, and B is a transmission coefficient ranging from 0.0 to 1.0. The coefficient is a function of the physical characteristics of the obstruction. Equations have been developed by the NAS to determine B for vegetation, buildings, natural barriers such as dunes, and man-made barriers such as breakwaters and seawalls (Reference 5).

The third concept deals with unimpeded reaches between obstructions. New wave generation can result from wind action. This added energy is related to distance and mean depth over the unimpeded reach.

These concepts and equations were used to compute wave heights and wave crest elevations associated with the 100-year storm surge. Accurate topographic, land-use, and land cover data are required for the wave height analysis. Maps of the study area at a scale of 1:2,400 with a contour interval of 2 feet were used for the topographic data (Reference 6). The land-use and land cover data were obtained through field surveys.

Wave heights were computed along transects which were located perpendicular to the average mean shoreline. The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, the transects were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects. Figure 17 illustrates the location of the transects for the community and Table 3 provides a physical description of the area along the shoreline represented by each transect.

Along each transect, wave heights and wave crest elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. Wave heights were calculated to the nearest 0.1 foot, and wave crest elevations were determined at whole-foot increments along the transects. The calculations were carried inland along the transect until the wave crest elevation was permanently less than 0.5 foot above the stillwater elevation. The results of the calculations are accurate until local topography, vegetation, or cultural development of the community undergo any major changes.

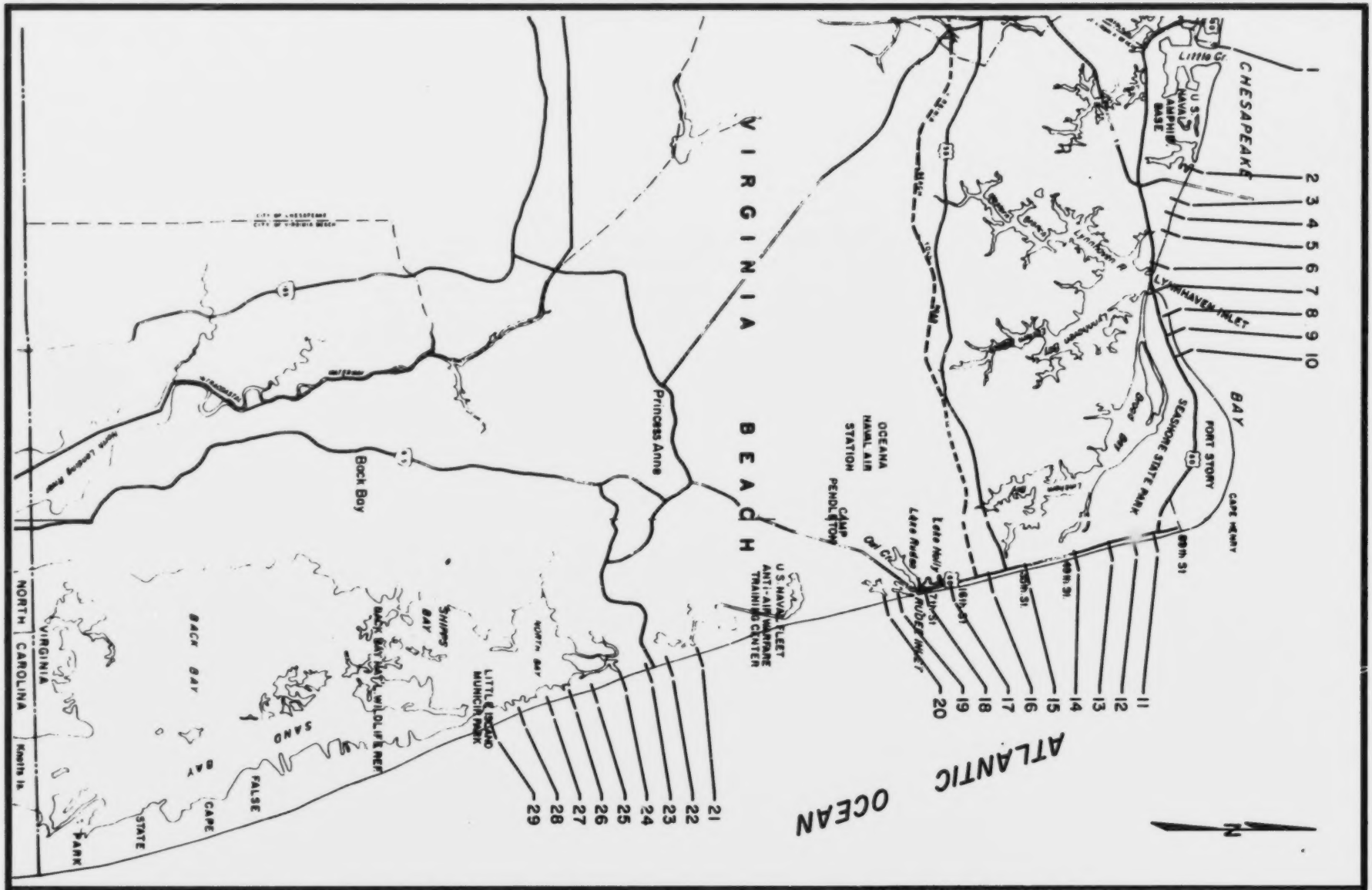


FIGURE 17

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA.

INDEPENDENT CITY

APPROXIMATE SCALE

2 0 2 4 6 MILES

TRANSECT LOCATION MAP

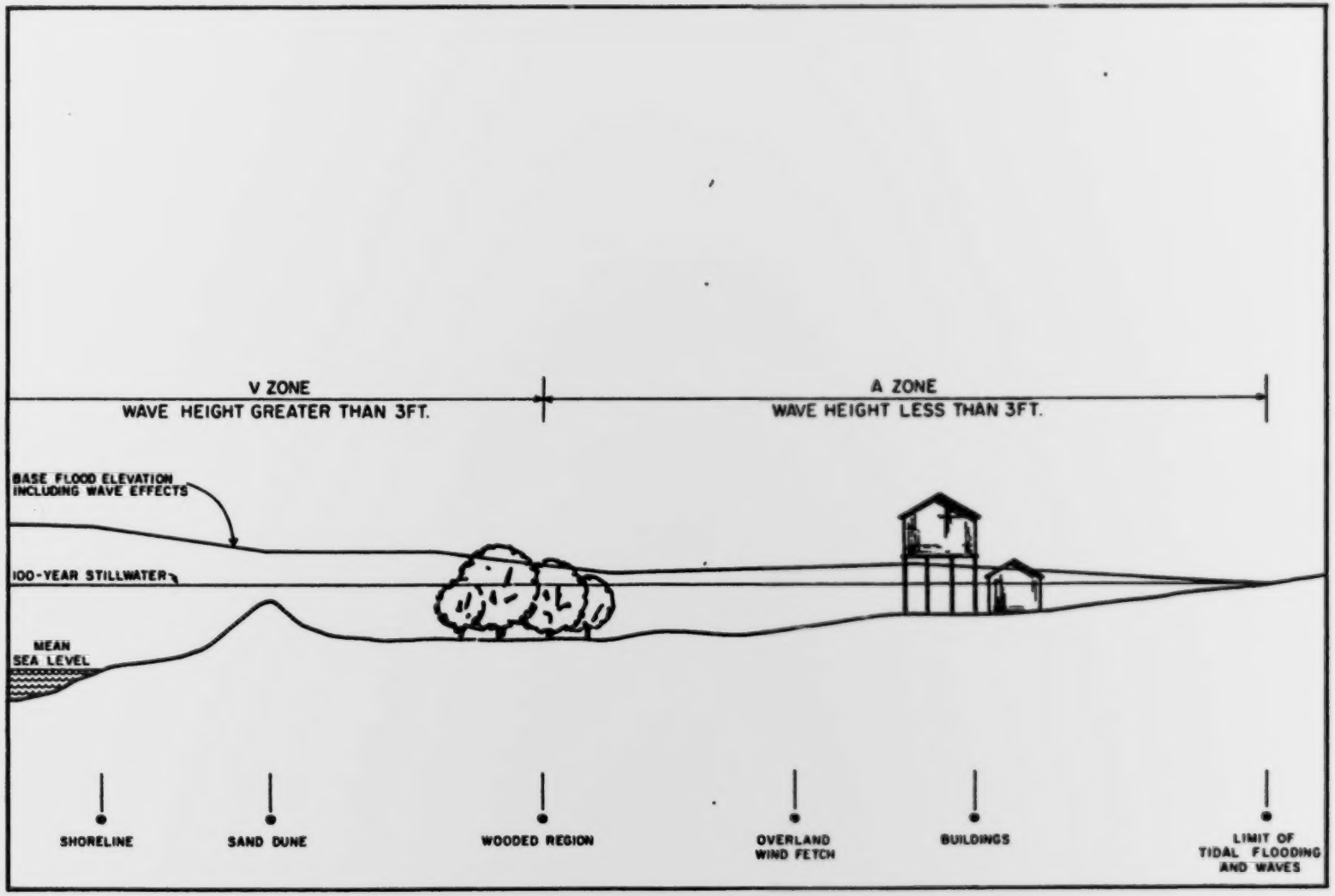


FIGURE 18
TYPICAL TRANSECT SCHEMATIC

TABLE 3 - TRANSECT DESCRIPTIONS

Transect	Location	Elevation (feet) Stillwater 100-year	Elevation (feet) Maximum Wave Crest 100-year
No. 1	From the eastern corporate limits to Little Creek	8.7	13
No. 2	From the U. S. Naval Amphibious Base boundary to the Chesapeake Bay Bridge Tunnel	8.7	13
No. 3	From the Chesapeake Bay Bridge Tunnel to Lee Avenue	8.7	13
No. 4	From Lee Avenue to Indian Hill Road	8.7	13
No. 5	From Indian Hill Road to Albemarle Avenue	8.7	13
No. 6	From Albemarle Avenue to Lynnhaven Inlet	8.7	13
No. 7	From Lynnhaven Inlet to Jade Street	8.7	13
No. 8	From Jade Street to Whaler Court	8.7	13
No. 9	From Whaler Court to Oak Street	8.7	13
No. 10	From Oak Street to Seashore State Park boundary	8.7	13
No. 11	From Fort Story boundary to 78th Street	8.7	13
No. 12	From 78th Street to 68th Street	8.7	13
No. 13	From 68th Street to 59th Street	8.7	13
No. 14	From 59th Street to 45th Street	8.7	13
No. 15	From 45th Street to Laskin Road	8.7	13
No. 16	From Laskin Road to 18th Street	8.7	13
No. 17	From 18th Street to 7th Street	8.7	13
No. 18	From 7th Street to Rudee Inlet	8.7	13
No. 19	From Rudee Inlet to Croatan Road	8.7	13
No. 20	From Croatan Road to Camp Pendleton State Military Reservation boundary	8.7	13
No. 21	From Fleet Anti-Air Warfare Training Center USN boundary to Bluefish Lane	8.7	13
No. 22	From Bluefish Lane to Sandbridge Road	8.7	13
No. 23	From Sandbridge Road to Bass Street	8.7	13
No. 24	From Bass Street to Tuna Lane	8.7	13
No. 25	From Tuna Lane to Rock Lane	8.7	13
No. 26	From Rock Lane to Pike Lane	8.7	13
No. 27	From Pike Lane to Molly Cooper Road	8.7	13
No. 28	From Molly Cooper Road to White Cap Lane	8.7	13
No. 29	From White Cap Lane to Back Bay National Wildlife Refuge boundary	8.7	13

Figure 18 represents a transect schematic and illustrates the relationships among the stillwater elevation, the wave crest elevation, the ground elevation profile, and the location of the A/V zone boundary.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps.

For areas studied by approximate methods, the extent of the 100-year flood was based on normal depth calculations, storage, previous studies, and familiarization and experience with similar streams in the study area.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages State and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study produces maps designed to assist communities in developing floodplain management measures.

4.1 Flood Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the 100- and 500-year floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps (Reference 6).

For tidal areas without wave action, the 100- and 500-year floodplain boundaries were delineated using the topographic maps (Reference 6). For the tidal areas with wave action, the floodplain boundaries were delineated using the elevations determined at each transect; between transects, boundaries were interpolated using engineering judgment, land-cover data, and the topographic maps (Reference 6). The 100-year floodplain was divided into whole-foot elevation zones based on the average wave envelope elevation in that zone. Where the map scale did not permit these zones to be delineated at one-foot intervals, larger increments were used.

For the flooding sources studied by approximate methods, the 100-year floodplain boundaries were delineated using the topographic maps referenced above. In the first revision, the 100-year floodplain boundary in the area known as Charlestowne Lakes South was redelineated using updated topographic mapping and a City of Virginia Beach flood hazard study based on a stormwater management plan (References 9, 10 and 11). In this revision, the 100-year floodplain boundary for the Stumpy Lake watershed was redelineated using the same mapping sources.

The 100- and 500-year flood plain boundaries are shown on the Flood Boundary and Floodway Map (Exhibit 2). In cases where the 100- and 500-year flood plain boundaries are close together, only the 100-year flood plain boundary has been shown. Small areas within the flood plain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

4.2 Floodways

Encroachment on flood plains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood plain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plain. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 4).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were computed at cross sections. Between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year flood plain boundaries are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and 100-year flood plain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain developments are shown in Figure 19.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY	INCREASE
Lake Smith Tributary								
A	60[1]	298	970	0.6	8.0	7.3[3]	8.3	1.0
B	1,555[1]	233	660	0.9	8.0	7.5[3]	8.3	0.8
C	2,870[1]	227	560	1.0	8.0	7.9[3]	8.5	0.6
D	4,630[1]	122	240	2.1	8.7	8.7	8.9	0.2
E	6,740[1]	78	80	4.6	12.1	12.1	12.1	0.0
F	7,460[1]	105	190	1.5	14.9	14.9	15.0	0.1
Thalia Creek								
A	1,900[2]	70	470	2.8	7.8	4.6[4]	5.4	0.8
B	2,795[2]	98	560	2.3	7.8	5.1[4]	6.0	0.9
C	3,840[2]	44	290	4.5	7.8	5.9[4]	6.8	0.9
D	4,515[2]	376	1,050	1.2	7.8	7.8	7.8	0.0
E	6,695[2]	86	566	2.0	7.9	7.9	7.9	0.0
F	8,527[2]	131	647	1.8	8.5	8.5	8.5	0.0

[1]Feet above confluence with Lake Smith

[2]Feet above Norfolk Southern Railroad

[3]Elevation computed without consideration of backwater effects from Lake Smith

[4]Elevation computed without consideration of backwater effects from Lynnhaven River

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA

(INDEPENDENT CITY)

FLOODWAY DATA

LAKE SMITH TRIBUTARY AND THALIA CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Left Bank Tributary Thalia Creek								
A	595	67	360	4.6	7.5	7.4[2]	8.4	1.0
B	1,100	40	260	6.1	8.1	8.1	8.7	0.6
C	2,643	67	390	3.7	10.4	10.4	10.6	0.2
D	4,450	66	440	2.9	11.3	11.3	11.4	0.1
E	5,335	90	540	2.2	11.5	11.5	11.6	0.1

[1]Feet above confluence with Thalia Creek

[2]Elevation computed without consideration of backwater effects from Thalia Creek

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOODWAY DATA

LEFT BANK TRIBUTARY THALIA CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Holland Road Tributary Thalia Creek								
A	587	42	250	4.2	11.6	7.4[2]	8.2	0.8
B	1,392	40	180	5.3	11.6	8.0[2]	8.6	0.6
C	1,624	60	430	2.1	11.7	11.7	11.7	0.0
D	2,960	200	1,650	0.5	11.8	11.8	11.8	0.0
E	3,284	77	430	1.7	12.7	12.7	12.7	0.0

[1]Feet above confluence with Left Bank Tributary Thalia Creek

[2]Elevation computed without consideration of backwater effects from Left Bank Tributary Thalia Creek

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOODWAY DATA

HOLLAND ROAD TRIBUTARY THALIA CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Kings Point System								
A	5,200	27	120	1.5	7.8	6.7[2]	7.7	1.0
B	5,490	19	80	1.9	7.8	6.9[2]	7.8	0.9
C	5,650	20	90	1.9	7.8	7.3[2]	8.2	0.9
D	6,170	27	120	1.3	7.8	7.7[2]	8.4	0.7
E	6,330	28	130	1.1	8.5	8.5	9.2	0.7
F	7,025	20	90	1.3	8.8	8.8	9.4	0.6
G	7,285	21	90	1.3	9.2	9.2	9.9	0.7
H	8,175	23	80	0.8	9.6	9.6	10.2	0.6

[1]Feet above confluence with Western Branch Lynnhaven River

[2]Elevation computed without consideration of backwater effects from Lynnhaven River

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA

(INDEPENDENT CITY)

FLOODWAY DATA

KINGS POINT SYSTEM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
						(FEET NGVD)		
Pine Tree Branch								
A	2,150	30	130	1.8	7.8	4.1[3]	5.1	1.0
B	2,710	215[2]	990	0.4	7.8	7.8	7.8	0.0
C	3,660	1 8[2]	700	0.6	7.9	7.9	7.9	0.0
D	4,790	209[2]	480	0.9	8.2	8.2	8.2	0.0

[1]Feet above confluence with Eastern Branch Lynnhaven River
[2]Storage-type analysis
[3]Elevation computed without consideration of backwater effects from Eastern Branch Lynnhaven River

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA

(INDEPENDENT CITY)

FLOODWAY DATA

PINE TREE BRANCH

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Canal No. 2- London Bridge Creek								
A	405[1]	74	660	4.6	7.8	5.9[3]	6.4	0.5
B	1,455[1]	136	1,020	3.0	7.8	7.1[3]	7.7	0.6
C	2,820[1]	113	1,320	2.3	7.9	7.9	8.6	0.7
D	3,690[1]	123	1,180	2.5	8.0	8.0	8.7	0.7
E	4,720[1]	195	2,090	1.3	8.3	8.3	9.0	0.7
F	6,660[1]	292	2,330	1.1	8.7	8.7	9.6	0.9
G	7,930[1]	206	1,780	1.4	8.9	8.9	9.8	0.9
H	9,335[1]	246	1,920	1.2	9.1	9.1	10.0	0.9
I	10,220[1]	191	1,530	1.4	9.2	9.2	10.1	0.9
J	11,490[1]	172	1,800	1.1	9.3	9.3	10.2	0.9
K	13,775[1]	250	2,070	0.8	9.4	9.4	10.3	0.9
L	14,450[1]	120	1,890	0.8	9.4	9.4	10.3	0.9
M	16,230[1]	113	1,610	0.8	9.4	9.4	10.3	0.9
Canal No. 2- West Neck Creek								
A	10,540[2]	2,870	11,670	0.5	5.0	4.9[4]	5.9	1.0
B	11,400[2]	1,555	7,090	0.7	5.1	5.1	6.0	0.9
C	14,850[2]	2,280	10,890	0.5	5.8	5.8	6.5	0.7

[1]Feet above Virginia Beach Boulevard

[2]Feet above West Neck Road

[3]Elevation computed without consideration of backwater effects from Lynnhaven River

[4]Elevation computed without consideration of backwater effects from Back Bay

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOODWAY DATA

CANAL NO. 2 - LONDON BRIDGE CREEK AND CANAL NO. 2 - WEST NECK CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Canal No. 2-West Neck Creek (continued)								
D	18,470[1]	1,590	8,290	0.6	6.5	6.5	7.1	0.6
E	20,380[1]	2,010	9,760	0.5	6.7	6.7	7.3	0.6
F	22,430[1]	1,420	8,020	0.6	6.9	6.9	7.5	0.6
G	24,210[1]	1,260	6,000	0.7	7.1	7.1	7.6	0.5
H	26,720[1]	901	5,750	0.7	7.5	7.5	8.1	0.6
I	30,350[1]	1,078	5,950	0.6	7.9	7.9	8.6	0.7
J	32,970[1]	985	5,770	0.5	8.1	8.1	8.8	0.7
K	35,380[1]	1,211	5,320	0.5	8.3	8.3	9.0	0.7
L	40,040[1]	717	3,950	0.6	8.7	8.7	9.5	0.8
M	43,680[1]	300	1,930	1.0	8.9	8.9	9.7	0.8
N	46,340[1]	320	1,930	0.8	9.3	9.3	10.3	1.0
O	47,400[1]	240	1,870	0.7	9.5	9.5	10.5	1.0
Holland Road Corridor System								
A	4,600[2]	117	740	0.5	9.4	6.8[3]	7.3	0.5
B	6,990[2]	96	510	0.8	9.4	7.6[3]	8.1	0.5
C	7,290[2]	107	620	0.6	9.4	8.5[3]	9.0	0.5
D	8,805[2]	133	960	0.4	9.4	9.0[3]	9.5	0.5

[1]Feet above West Neck Road

[2]Feet above confluence with Green Run Canal

[3]Elevation computed without consideration of backwater effects from Canal No. 2-London Bridge Creek

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA

(INDEPENDENT CITY)

FLOODWAY DATA

CANAL NO. 2 - WEST NECK CREEK AND HOLLAND ROAD CORRIDOR SYSTEM

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Green Run Canal								
A	310[1]	36	210	2.7	9.5	6.0[4]	6.8	0.8
B	1,035[1]	42	220	2.6	9.5	6.4[4]	7.1	0.7
C	2,005[1]	48	320	1.8	9.5	6.9[4]	7.5	0.6
D	2,445[1]	36	200	2.9	9.5	7.0[4]	7.6	0.6
E	2,780[1]	69	270	2.1	9.5	8.3[4]	8.9	0.6
F	3,550[1]	76	320	1.8	9.5	8.8[4]	9.2	0.4
G	3,950[1]	188[3]	760	1.2	9.6	9.6	9.6	0.0
H	5,572[1]	126[3]	650	1.4	9.8	9.8	9.8	0.0
I	7,035[1]	186[3]	830	1.1	10.1	10.1	10.1	0.0
J	7,400[1]	273[3]	960	1.0	10.3	10.3	10.3	0.0
K	9,400[1]	281[3]	1,010	0.9	10.5	10.5	10.5	0.0
Mill Dam Creek								
A	5,802[2]	336[3]	1,490	0.5	8.1	8.1	8.1	0.0
B	6,445[2]	266[3]	1,100	0.7	8.2	8.2	8.2	0.0
C	6,918[2]	345[3]	1,110	0.7	8.2	8.2	8.2	0.0
D	7,902[2]	910[3]	870	0.8	8.5	8.5	8.5	0.0
E	8,520[2]	199[3]	510	1.4	8.9	8.9	8.9	0.0
F	9,680[2]	68	260	2.6	10.2	10.2	10.6	0.4
G	9,930[2]	58	340	2.0	13.0	13.0	13.4	0.4
H	10,790[2]	53	190	3.6	13.9	13.9	14.2	0.3
I	11,468[2]	38	200	3.5	15.4	15.4	15.5	0.1

[1]Feet above confluence with Canal No. 2-West Neck Creek

[2]Feet above confluence with Broad Bay

[3]Storage-type analysis

[4]Elevation computed without consideration of backwater effects from Canal No. 2-West Neck Creek

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA

(INDEPENDENT CITY)

FLOODWAY DATA

GREEN RUN CANAL AND MILL DAM CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Canal No. 1 North								
A	4,430	356[2]	1,640	0.9	9.4	9.4	9.4	0.0
B	4,965	412[2]	1,490	0.4	9.5	9.5	9.5	0.0
C	6,085	325[2]	980	0.6	9.6	9.6	9.6	0.0
D	6,790	106	470	1.2	9.8	9.8	10.8	1.0
E	7,260	104	320	1.7	10.1	10.1	11.1	1.0
F	7,910	84	250	2.1	11.3	11.3	12.3	1.0
G	8,930	132	450	1.1	12.5	12.5	13.4	0.9

[1]Feet above Virginia Beach Toll Road
[2]Storage-type analysis

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA

(INDEPENDENT CITY)

FLOODWAY DATA

CANAL NO. 1 NORTH

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Fox Run Canal								
A	1,219	65	210	4.5	8.4	6.8[3]	7.0	0.2
B	1,735	61	190	5.0	8.8	8.8	8.8	0.0
C	2,240	65	280	3.3	10.4	10.4	10.5	0.1
D	2,650	40	210	3.9	11.1	11.1	11.1	0.0
E	3,972	46	240	3.0	12.9	12.9	13.0	0.1
F	4,655	44	240	2.9	13.6	13.6	13.7	0.1
G	5,618	60	380	1.6	14.2	14.2	14.2	0.0
H	6,215	69	400	1.3	14.3	14.3	14.3	0.0
Lake Banbury								
A	5,545	242[2]	1,200	0.6	8.9	8.9	8.9	0.0
B	5,953	173[2]	850	0.6	8.9	8.9	8.9	0.0
C	6,110	113[2]	600	0.8	9.0	9.0	9.3	0.3
D	6,650	197[2]	1,030	0.5	15.6	15.6	15.6	0.0
Cedar Hill Canal								
A	3,630	52	180	1.8	8.5	6.0[3]	7.0	1.0
B	4,205	63	180	1.6	8.5	6.4[3]	7.1	0.7
C	4,580	27	100	3.1	8.5	6.8[3]	7.4	0.6
D	4,680	33	120	2.3	8.5	7.0[3]	7.5	0.5
E	5,080	26	110	2.3	8.7	8.7	9.1	0.4
F	5,680	20	80	2.7	9.2	9.2	9.5	0.3

[1]Feet above confluenc with Eastern Branch Elizabeth River

[2]Storage-type analysis

[3]Elevation computed without consideration of backwater effects from Eastern Branch Elizabeth River

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOODWAY DATA

FOX RUN CANAL, LAKE BANBURY AND CEDAR HILL CANAL

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Cedar Hill Canal (continued)								
G	6,180[1]	23	70	2.9	9.8	9.8	10.0	0.2
H	6,970[1]	23	50	3.2	11.1	11.1	11.1	0.0
I	7,630[1]	30	50	2.5	12.7	12.7	12.7	0.0
J	8,280[1]	24	50	1.9	13.6	13.6	13.6	0.0
K	8,510[1]	26	40	2.4	13.8	13.8	13.8	0.0
L	12,200[1]	50	300	4.8	13.8	13.8	14.8	1.0
M	13,200[1]	56	330	3.9	15.4	15.4	15.7	0.3
N	14,200[1]	56	340	3.5	16.7	16.7	16.9	0.2
Salem Canal								
A	300[2]	763	3,100	0.7	5.0	5.0	5.6	0.6
B	900[2]	620	2,810	0.8	5.0	5.0	5.6	0.6
C	2,250[2]	510	2,140	1.0	5.3	5.3	5.9	0.6
D	4,200[2]	490	2,220	0.9	5.7	5.7	6.3	0.6
E	5,540[2]	540	2,850	0.7	5.8	5.8	6.6	0.8
F	7,098[2]	537	2,690	0.7	5.9	5.9	6.7	0.8
G	7,975[2]	410	2,150	0.8	5.9	5.9	6.8	0.9
H	9,228[2]	349	1,740	1.0	6.1	6.1	7.0	0.9
I	10,736[2]	380	2,050	0.8	6.3	6.3	7.2	0.9
J	11,955[2]	380	1,840	0.8	6.7	6.7	7.7	1.0

[1]Feet above confluence with Eastern Branch Elizabeth River
[2]Feet above Indian River Road

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOODWAY DATA

CEDAR HILL CANAL AND SALEM CANAL

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Salem Canal (continued)								
K	13,520[1]	300	1,450	0.8	6.7	6.7	7.7	1.0
L	14,735[1]	300	1,150	0.9	6.9	6.9	7.9	1.0
M	16,437[1]	300	1,150	0.8	7.3	7.3	8.2	0.9
N	17,110[1]	100	350	2.3	7.5	7.5	8.3	0.8
O	18,279[1]	100	460	1.4	8.4	8.4	9.2	0.8
P	19,210[1]	100	560	1.0	8.6	8.6	9.4	0.8
Q	20,200[1]	100	610	0.9	8.7	8.7	9.5	0.8
R	21,475[1]	100	340	1.3	9.1	9.1	9.7	0.6
S	22,480[1]	56	240	1.7	9.3	9.3	10.1	0.8
T	23,304[1]	60	280	1.2	9.5	9.5	10.3	0.8
U	24,075[1]	61	320	0.9	9.6	9.6	10.4	0.8
Canal No. 4								
A	1,560[2]	155	600	4.1	5.1	4.0[3]	4.8	0.8
B	2,295[2]	244	1,190	2.0	5.2	5.2	6.2	1.0
C	3,130[2]	217	1,090	2.2	5.7	5.7	6.6	0.9
D	3,600[2]	152	860	2.8	6.1	6.1	7.0	0.9
E	3,890[2]	174	830	2.9	6.7	6.7	7.3	0.6
F	4,175[2]	161	990	2.4	6.9	6.9	7.6	0.7
G	4,875[2]	112	510	1.1	7.4	7.4	8.1	0.7
H	5,500[2]	48	260	2.1	7.5	7.5	8.2	0.7

[1]Feet above Indian River Road
[2]Feet above confluence with Salem Canal
[3]Elevation computed without consideration of backwater effects from Salem Canal

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOODWAY DATA

SALEM CANAL AND CANAL NO. 4

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Canal No. 4 (continued)								
I	5,780[1]	43	230	2.3	7.6	7.6	8.3	0.7
J	6,200[1]	47	250	2.0	7.9	7.9	8.5	0.6
K	6,850[1]	57	300	1.5	8.1	8.1	8.7	0.6
L	7,020[1]	60	300	1.5	8.2	8.2	8.8	0.6
M	7,700[1]	41	180	2.2	8.4	8.4	8.9	0.5
N	8,440[1]	28	120	3.0	8.9	8.9	9.3	0.4
O	9,690[1]	51	180	1.6	9.8	9.8	10.0	0.2
P	10,600[1]	29	120	1.9	10.1	10.1	10.3	0.2
Q	11,300[1]	28	110	1.7	10.4	10.4	10.5	0.1
R	11,875[1]	36	130	1.0	10.6	10.6	10.7	0.1
S	12,500[1]	22	100	1.1	10.7	10.7	10.7	0.0
T	13,300[1]	25	100	0.5	10.8	10.8	10.8	0.0
U	13,875[1]	48	120	0.2	10.8	10.8	10.9	0.1
Colony Acres Canal								
A	800[2]	179	710	2.3	8.0	7.1[3]	8.0	0.9
B	2,025[2]	319	1,040	1.6	8.2	8.2	9.1	0.9
C	2,868[2]	298	930	1.7	8.4	8.4	9.3	0.9
D	3,685[2]	212	750	2.2	9.3	9.3	10.1	0.8
E	5,127[2]	104	560	2.9	11.1	11.1	11.5	0.4

[1]Feet above confluence with Salem Canal

[2]Feet above confluence with Canal No. 2-West Neck Creek

[3]Elevation computed without consideration of backwater effects from Canal No. 2-West Neck Creek

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA

(INDEPENDENT CITY)

FLOODWAY DATA

CANAL NO. 4 AND COLONY ACRES CANAL

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Colony Acres Canal (continued)								
F	5,812	60	400	4.1	11.8	11.8	12.1	0.3
G	6,542	100	650	2.5	12.9	12.9	13.4	0.5
H	7,460	79	530	3.1	13.4	13.4	14.0	0.6

[1]Feet above confluence with Canal No. 2-West Neck Creek

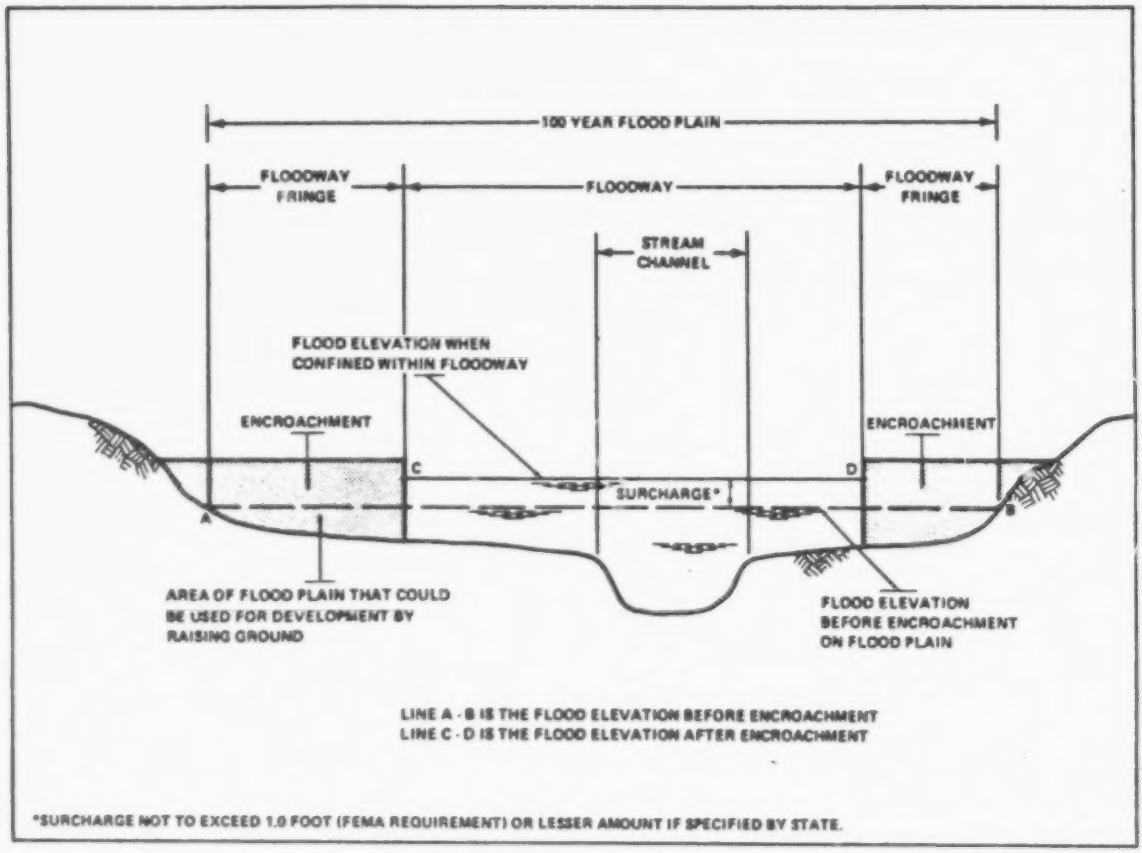
TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOODWAY DATA

COLONY ACRES CANAL


100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE A - B IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE C - D IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

FLOODWAY SCHEMATIC - Figure 19

Near the mouths of streams studied in detail, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, "Without Floodway" elevations presented in Table 4 for certain downstream cross sections of Lake Smith Tributary, Thalia Creek, Left Bank Tributary Thalia Creek, Holland Road Tributary Thalia Creek, Kings Point System, Pine Tree Branch, Canal No. 2-London Bridge Creek, Canal No. 2-West Neck Creek, Holland Road Corridor System, Green Run Canal, Fox Run Canal, Cedar Hill Canal, Canal No. 4, and Colony Acres Canal are lower than the regulatory flood elevations in that area, which must take into account the 100-year flooding due to backwater from other sources.

Due to the unusual flooding conditions for Lake Pembroke, no floodway was delineated.

5.0 INSURANCE APPLICATION

To establish actuarial insurance rates, data from the engineering study must be transformed into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail in the City of Virginia Beach.

5.1 Reach Determinations

Reaches are defined as sections of flood plain that have relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference may not have a variation greater than that indicated in the following tabulation for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the riverine flooding sources of the City of Virginia Beach are shown on the Flood Profiles (Exhibit 1) and summarized in Table 5A.

In tidal areas, where no wave height analysis was performed, reaches are limited to the distance for which the difference between the 10- and 100-year flood elevations does not vary more than 1.0 foot. Using these criteria, the entire shorelines of the Eastern Branch Elizabeth River, Lake Smith, Lynnhaven Bay, the Lynnhaven River, Broad Bay, Linkhorn Bay, Rudee Inlet, Lake Holly, Back Bay, Chubb Lake, Bradford Lake, and Lake Taylor each qualify as one reach.

In areas where wave height and wave runup analyses were performed, reaches were determined for areas of the coastline, represented by a transect or group of transects, which have the same physical characteristics. The reaches determined for the tidal flooding sources in the City of Virginia Beach are summarized in the Flood Insurance Zone Data Table (Table 5B).

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is used to establish relationships between depth and frequency of flooding in any reach. This relationship is then used with depth-damage relationships for various classes of structures to establish actuarial insurance rate tables.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Lake Smith Tributary Reach 1	12, 16	-0.5	-0.1	+0.3	005	A1	Varies
Lake Pembroke Reach 1	17	-2.1	-0.7	+1.6	020	A4	10
Thalia Creek Reach 1	23	-1.1	-0.3	+0.6	010	A2	Varies
Left Bank Tributary Thalia Creek Reach 1	23	-1.8	-0.5	+1.2	020	A4	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

TABLE 5A

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA

(INDEPENDENT CITY)

FLOOD INSURANCE ZONE DATA

LAKE SMITH TRIBUTARY, LAKE PEMBROKE, THALIA CREEK, AND LEFT BANK TRIBUTARY THALIA CREEK

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Holland Road Tributary Thalia Creek Reach 1	23,29	-0.9	-0.2	+0.6	010	A2	Varies
Kings Point System Reach 1	18	-2.1	-0.7	+1.7	020	A4	Varies
Pine Tree Branch Reach 1	18,24	-1.6	-0.5	+1.6	015	A3	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

TABLE 5A

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA

(INDEPENDENT CITY)

FLOOD INSURANCE ZONE DATA

HOLLAND ROAD TRIBUTARY THALIA CREEK, KINGS POINT SYSTEM AND PINE TREE BRANCH

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Canal No. 2 - London Bridge Creek							
Reach 1	18,24, 25,29, 30	-2.3	-0.6	+1.3	025	A5	Varies
Canal No. 2 - West Neck Creek							
Reach 1	30,35 36,37, 41,42, 47	-1.3	-0.4	+0.9	015	A3	Varies
Green Run Canal							
Reach 1	29,30	-1.8	-0.6	+1.1	020	A4	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

TABLE 5A

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD INSURANCE ZONE DATA

CANAL NO. 2 - LONDON BRIDGE CREEK,
CANAL NO. 2 - WEST NECK CREEK AND GREEN RUN CANAL

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Mill Dam Creek							
Reach 1	14, 19	-1.5	-0.5	+1.2	015	A3	Varies
Canal No. 1 North							
Reach 1	25, 26	-1.0	-0.3	+0.8	010	A2	Varies
Fox Run Canal							
Reach 1	22	-1.6	-0.5	+1.1	015	A3	Varies
Lake Banbury							
Reach 1	21, 27	-2.0	-0.7	+1.4	020	A4	Varies
Reach 2	27	-0.9	-0.5	+1.5	010	A2	Varies
Reach 3	27	-2.0	-0.7	+1.0	020	A4	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

TABLE 5A

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH , VA
(INDEPENDENT CITY)

FLOOD INSURANCE ZONE DATA

MILL DAM CREEK , CANAL NO. 1 NORTH , FOX RUN CANAL AND LAKE BANBURY

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Cedar Hill Canal Reach 1	27	-1.3	-0.5	+1.1	015	A3	Varies
Salem Canal Reach 1	28,29, 34,35, 40	-0.9	-0.3	+0.5	010	A2	Varies
Canal No. 4 Reach 1	35,40	-1.3	-0.3	+0.9	015	A3	Varies
Colony Acres Canal Reach 1	36	-1.0	-0.3	+0.6	010	A2	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

TABLE 5A

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH , VA

(INDEPENDENT CITY)

FLOOD INSURANCE ZONE DATA

CEDAR HILL CANAL , SALEM CANAL , CANAL NO. 4 AND COLONY ACRES CANAL

TABLE 5B - FLOOD INSURANCE ZONE DATA

Flooding Source	Stillwater Elevation 10-Year	Stillwater Elevation 100-Year	FHF	Zone	Base Flood Elevation (Feet NGVD)*
Chesapeake Bay					
Transect 1	6.5	8.7	035	V7	11-13
			030	A6	9-10
Transects 2-10			035	V7	11-13
			035	A7	9-10
Atlantic Ocean					
Transects 11-29	6.5	8.7	035	V7	11-13
			035	A7	9-11
Eastern Branch Elizabeth River	6.4	8.5	030	A6	9
			020	A4	8.5
Lake Smith	5.5	8.0	025	A5	8
Lynnhaven Bay	5.9	7.8	020	A4	8
Lynnhaven River	5.9	7.8	020	A4	8
Broad Bay	5.3	6.9	015	A3	7
Linkhorn Bay	5.3	6.9	015	A3	7
Lake Rudee	6.5	8.7	020	A4	9
Lake Holly					
South of Southern Boulevard	5.5	8.0	025	A5	8
North of Southern Boulevard	4.5	7.0	025	A5	7
Back Bay	3.3	5.0	015	A3	5
Chubb Lake	5.5	8.0	025	A5	8
Bradford Lake	5.5	8.0	025	A5	8
Lake Taylor	6.4	8.5	020	A4	8.5

*Due to map scale limitations, base flood elevations shown on the FIRM represent average elevations for the zones depicted.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations rounded to the nearest one-half foot, multiplied by 10, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year flood water-surface elevations is greater than 10.0 feet, it is rounded to the nearest whole foot.

5.3 Flood Insurance Zones

Flood insurance zones and zone numbers are assigned based on the type of flood hazard and the FHF, respectively. A unique zone number is associated with each possible FHF, and varies from 1 for a FHF of 005 to a maximum of 30 for a FHF of 200 or greater.

Zone A:	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.
Zones A1, A2, A3, A4, A5, A6, and A7:	Special Flood Hazard Areas inundated by the 100-year flood; with base flood elevations shown, and zones subdivided according to FHFs.
Zone V7:	Special Flood Hazard Areas along coasts inundated by the 100-year flood that have additional velocity hazards associated with waves of 3-foot amplitude or greater; with base flood elevations shown, and zones subdivided according to FHFs.
Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood; areas that are protected from the 100- or 500-year floods by dike, levee, or other water control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding; not subdivided.

Flood elevation differences, FHFs, flood insurance zones, and base flood elevations for the flooding sources studied in detail in the community are shown in Tables 5A and 5B.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Virginia Beach is, for insurance purposes, the principal result of the Flood Insurance Study. This map contains the official delineation of flood insurance zones and base flood elevations. Base flood elevation lines show the locations of the expected whole-foot water-surface elevation of the base (100-year) flood. The base flood elevations and zone numbers are used by insurance agents, in conjunction with structure elevations and characteristics, to assign actuarial insurance rates to structures and contents insured under the National Flood Insurance Program.

6.0 OTHER STUDIES

A Flood Plain Information Report for Virginia Beach was prepared by the COE in July 1969 (Reference 3). A number of other reports have been prepared by the Norfolk District of the COE concerning flooding in Virginia Beach, including a feasibility report for beach erosion control and hurricane protection, a feasibility report for flood control and navigation, and a study of Canal Number Two (References 12, 13 and 14). FEMA requested that the National Oceanic and Atmospheric Administration study flood levels from storm tides on the open coasts of Virginia, Maryland and Delaware. This study was completed in August 1976 (Reference 15).

Flood Insurance Studies have been prepared for the Cities of Norfolk and Chesapeake (References 16 and 17). Because of differences in map bases, there are minor discrepancies at the Norfolk-Virginia Beach corporate limits. Because of more accurate approximate analyses and more detailed topographic information, the floodplain boundaries in this study are not in agreement with those in the Chesapeake study.

Because it is based on more up-to-date analyses, this study supersedes the previously printed Flood Insurance Study for the City of Virginia Beach (Reference 18).

7.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting FEMA, the Natural and Technological Hazards Division, Liberty Square Building (Second Floor), 105 South Seventh Street, Philadelphia, Pennsylvania 19106.

8.0 BIBLIOGRAPHY AND REFERENCES

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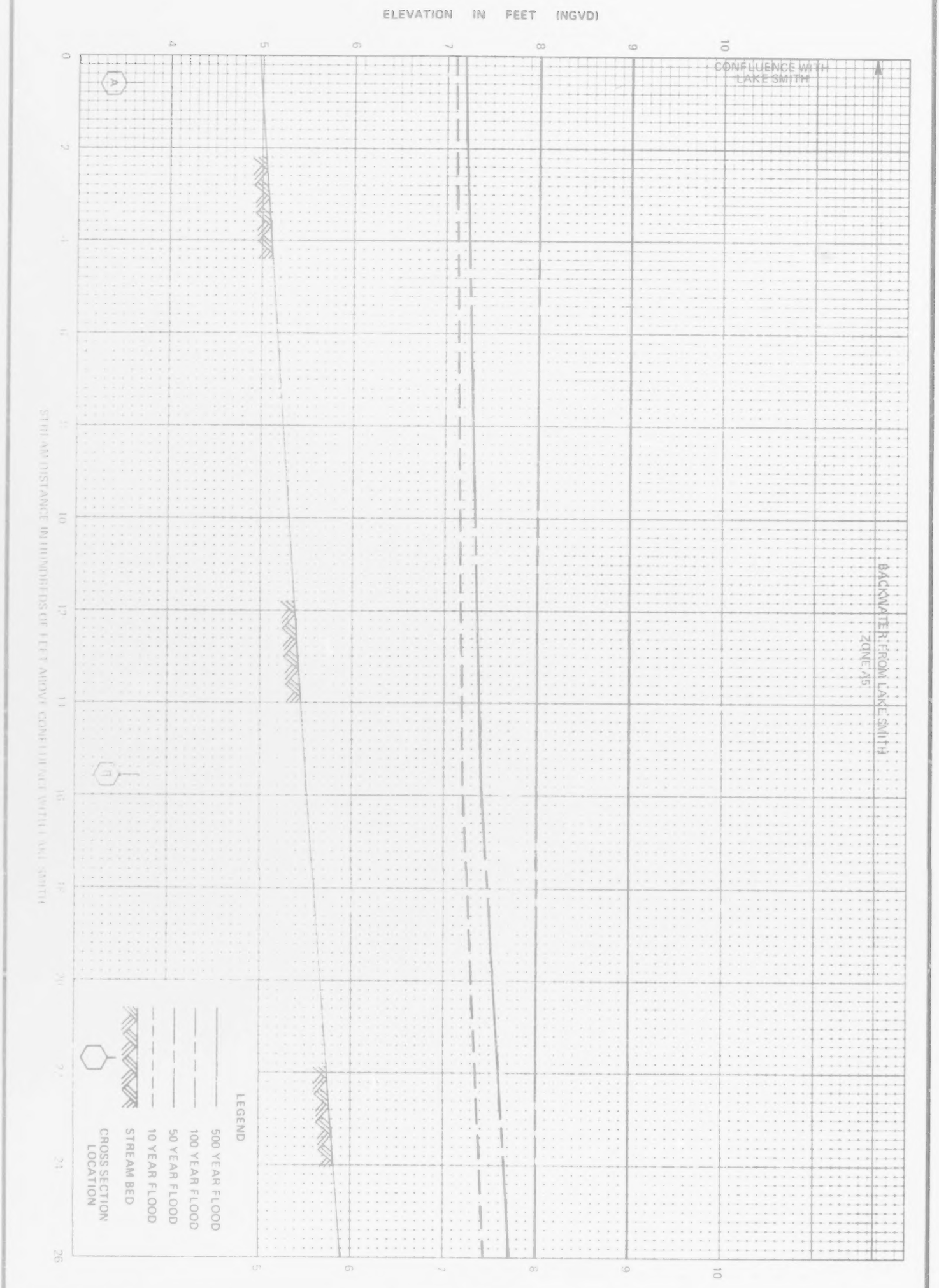


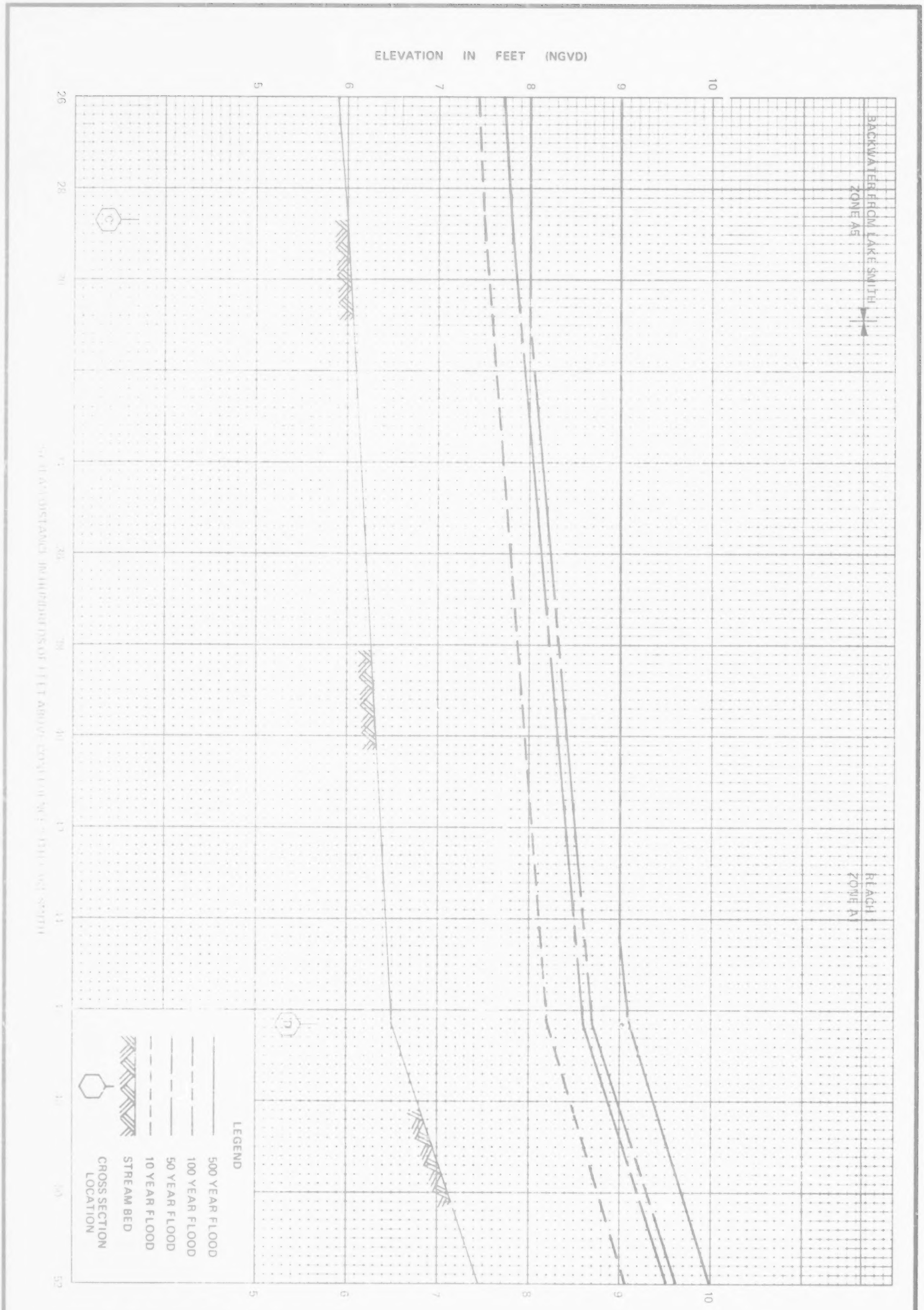
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

LAKE SMITH TRIBUTARY

01P



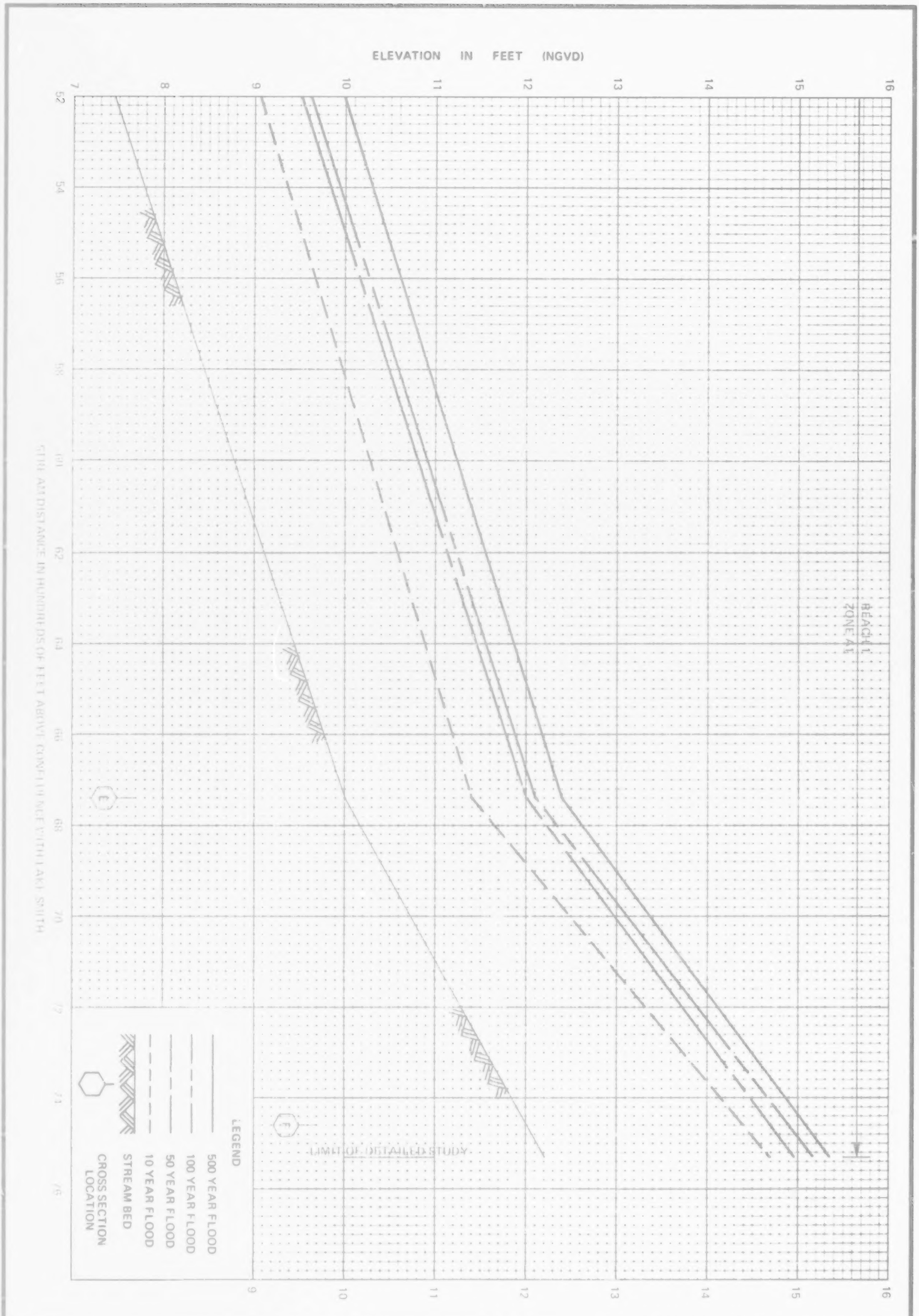
02P

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

LAKE SMITH TRIBUTARY



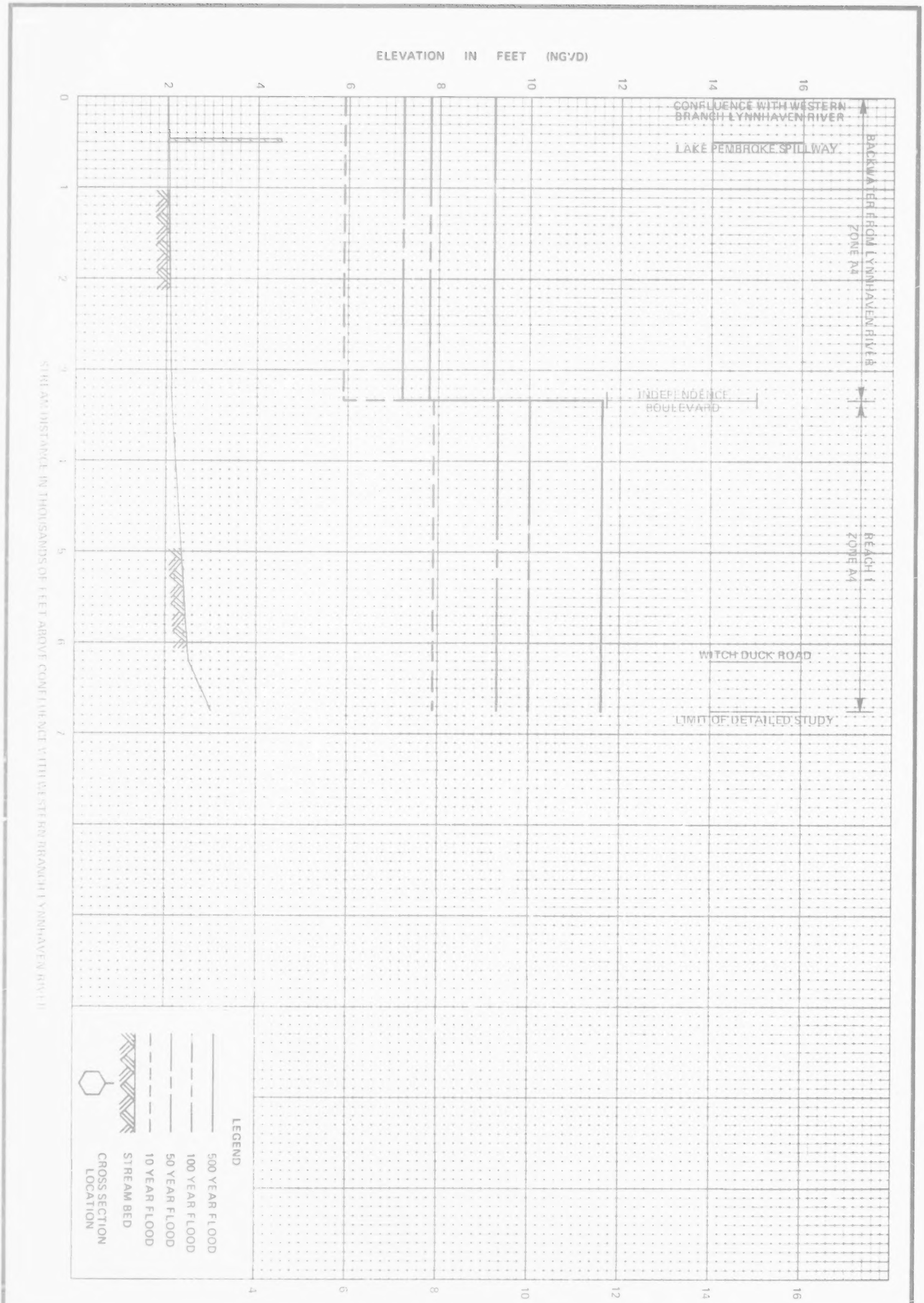
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

03P

FLOOD PROFILES

LAKE SMITH TRIBUTARY



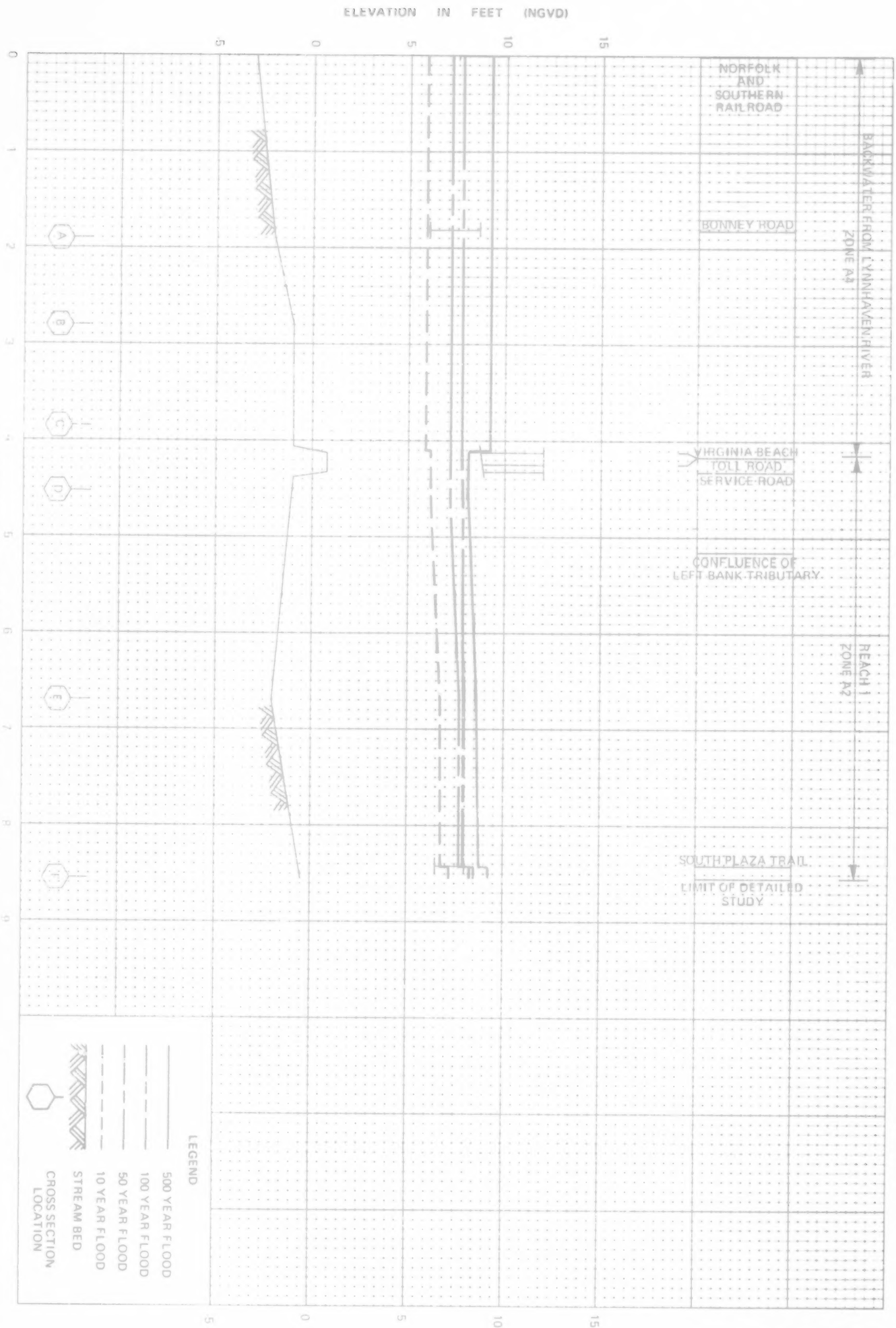
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

LAKE PEMBROKE

04P



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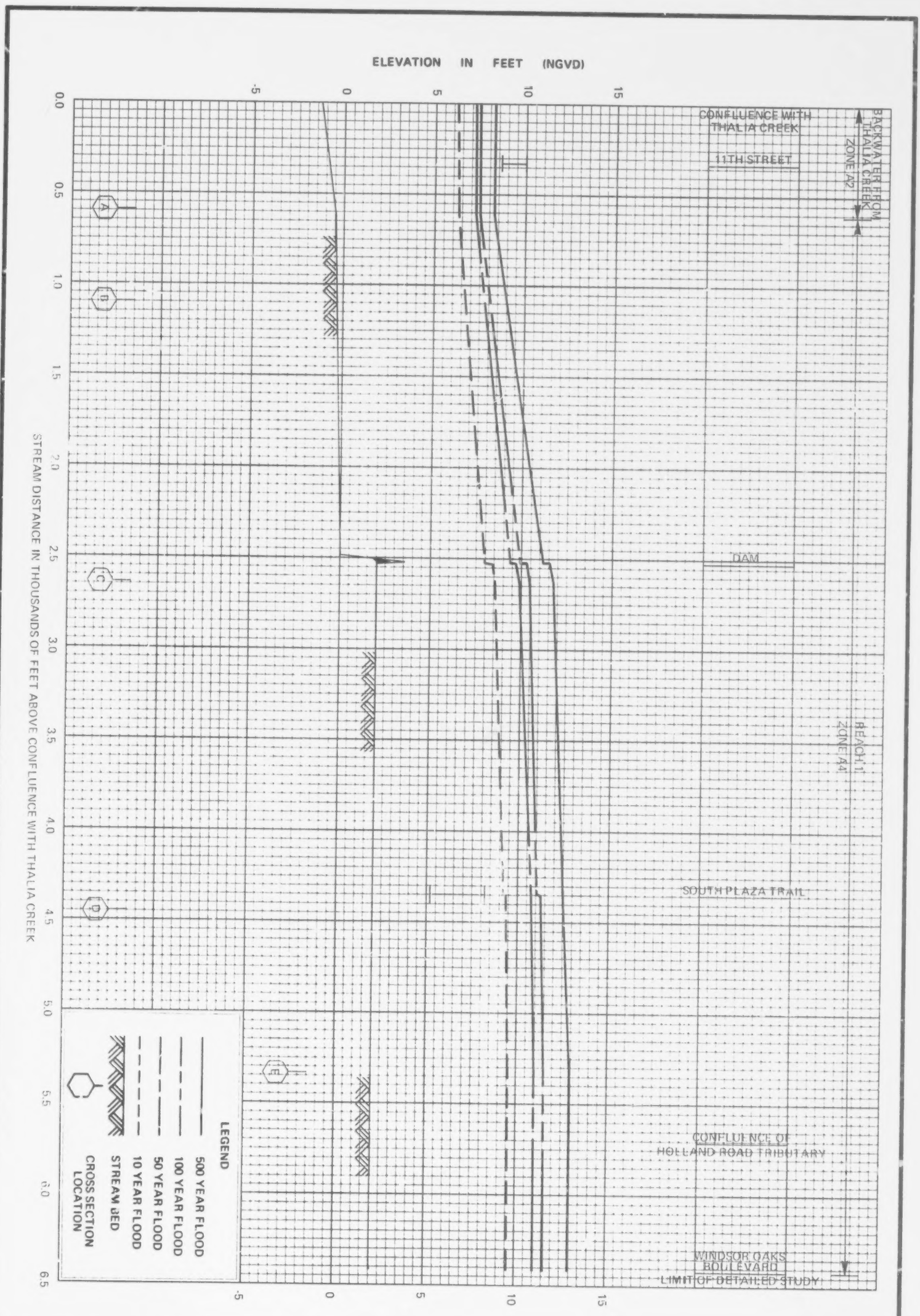
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

THALIA CREEK



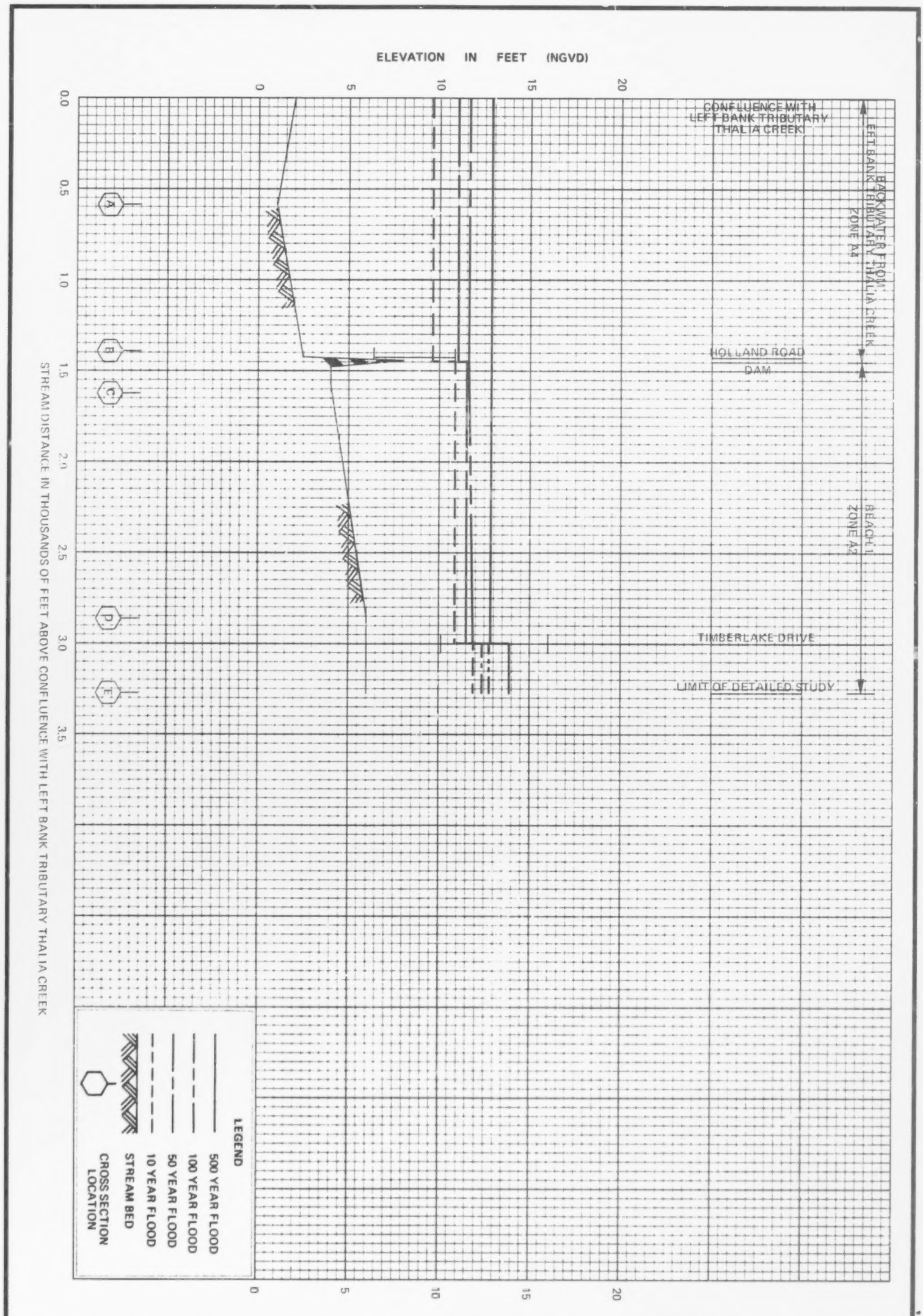
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

LEFT BANK TRIBUTARY THALIA CREEK

06P



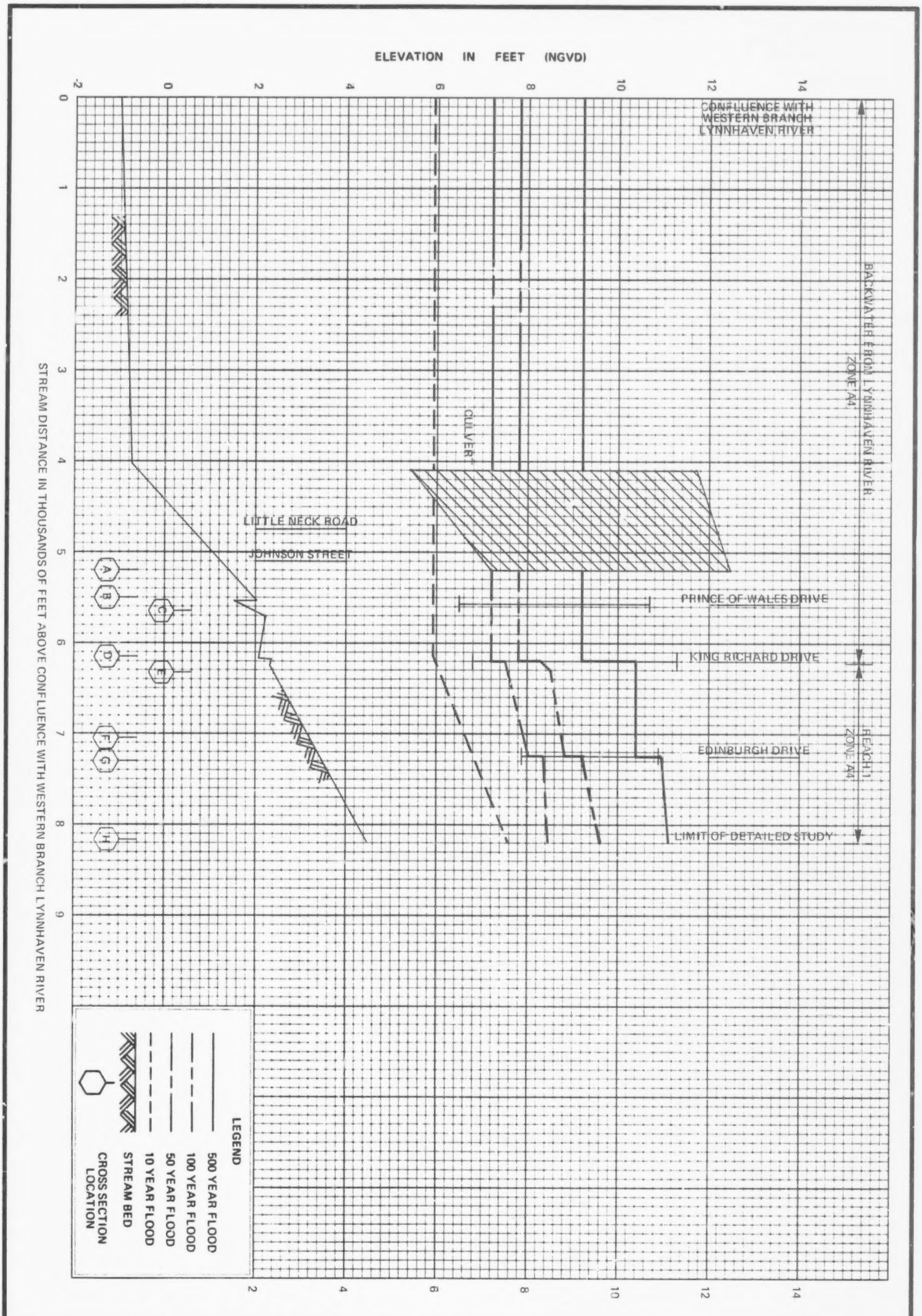
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

HOLLAND ROAD TRIBUTARY THALIA CREEK

07P



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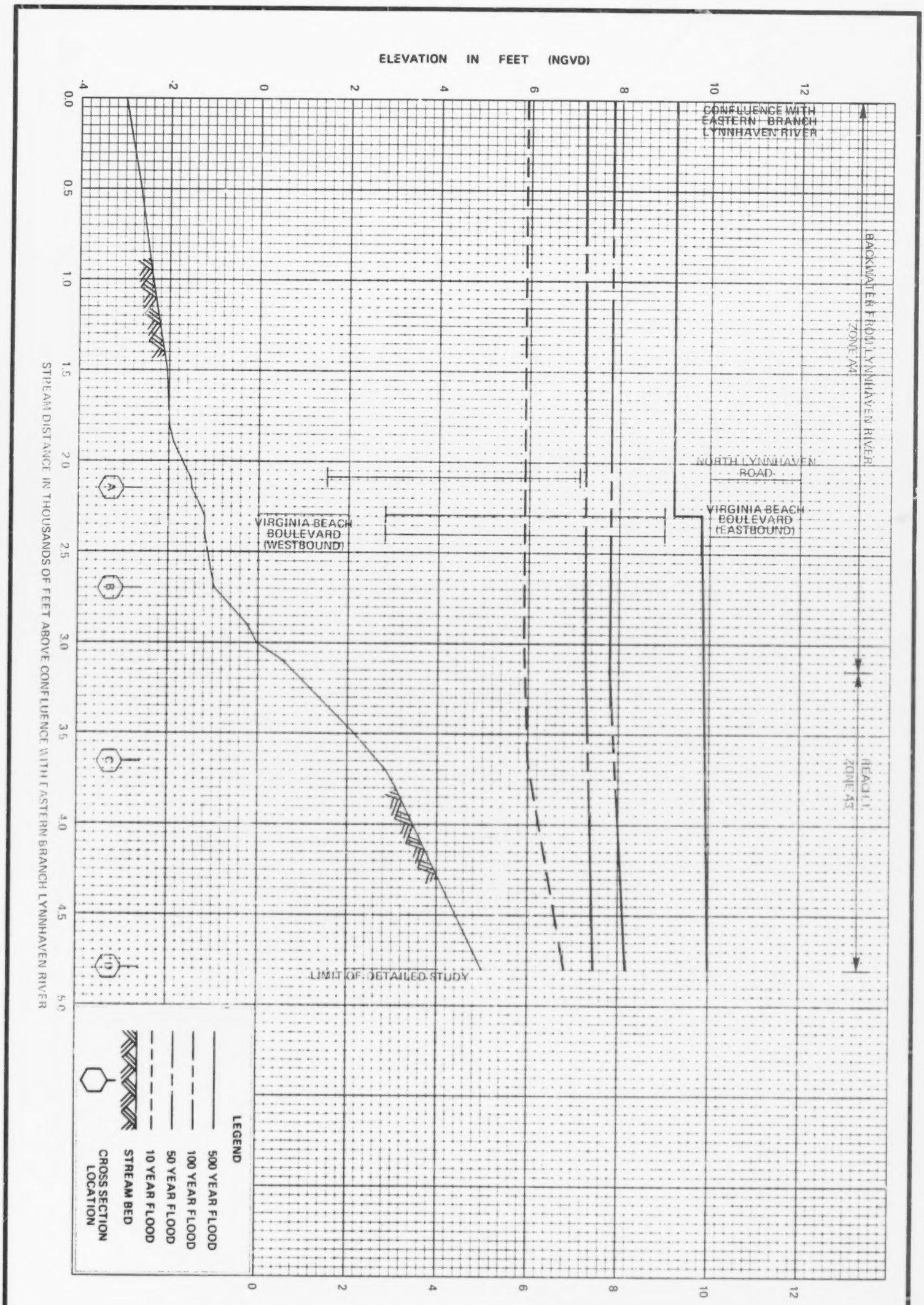
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

KINGS POINT SYSTEM



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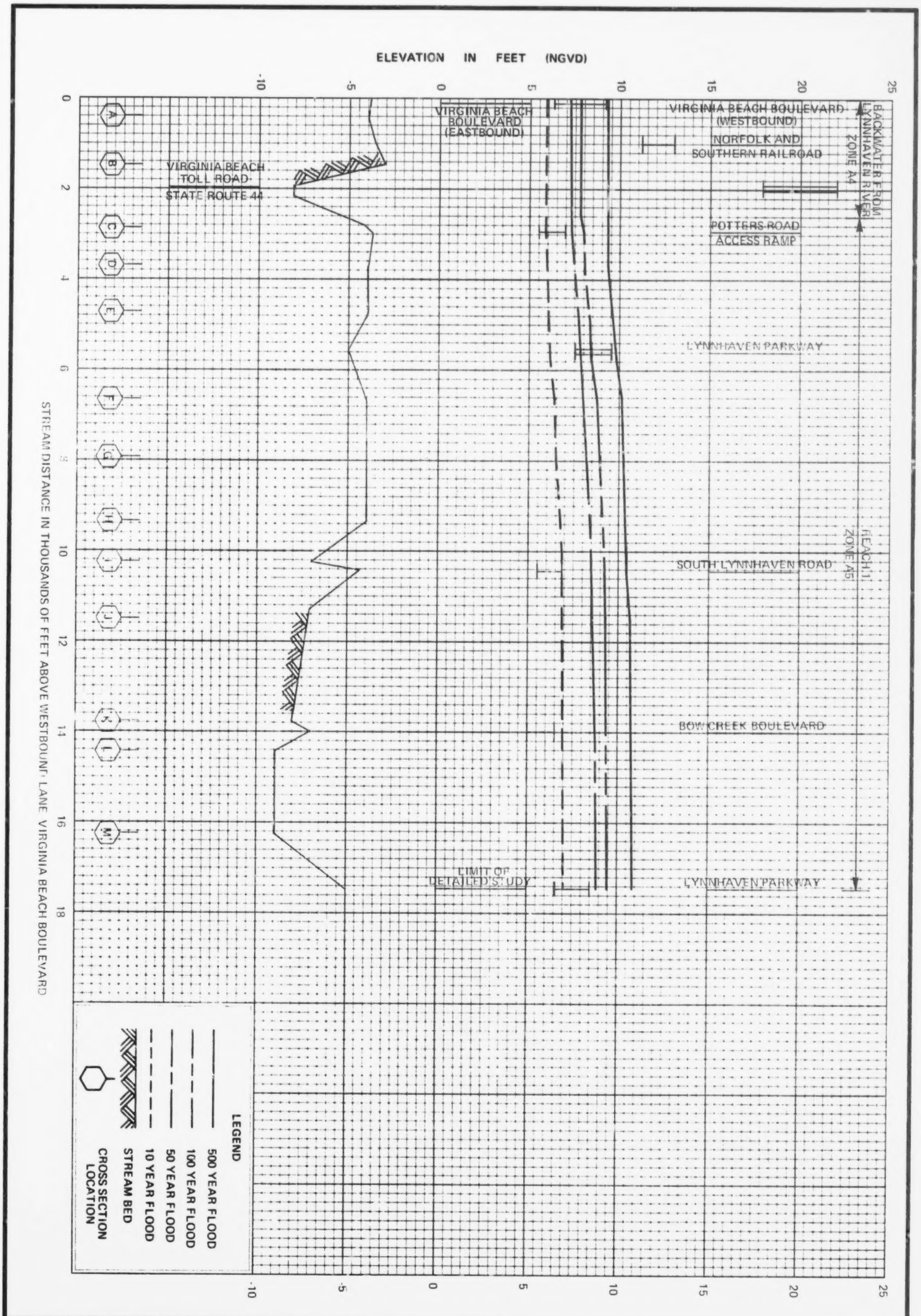
CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

PINE TREE BRANCH



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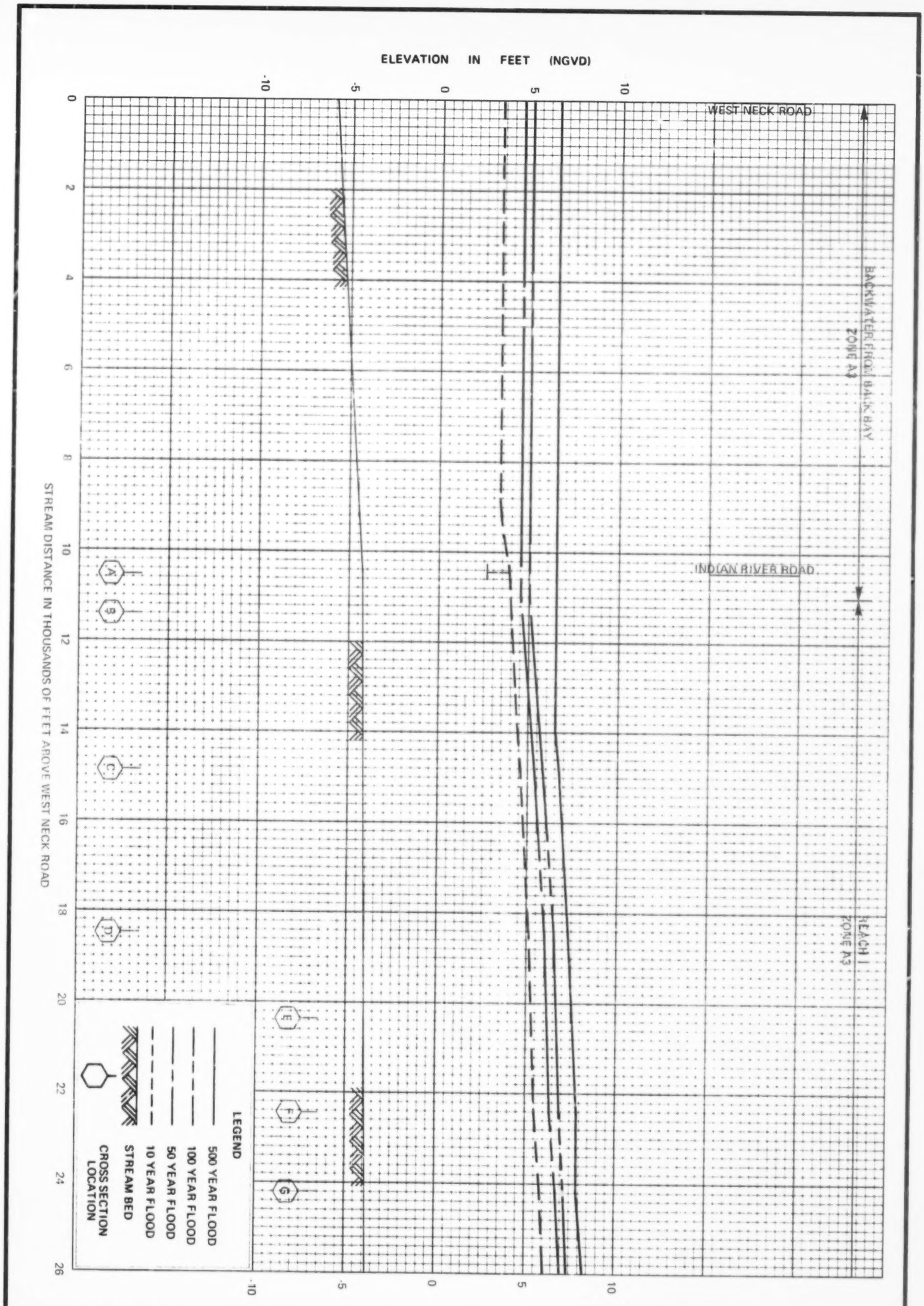
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

CANAL NO. 2 -LONDON BRIDGE CREEK



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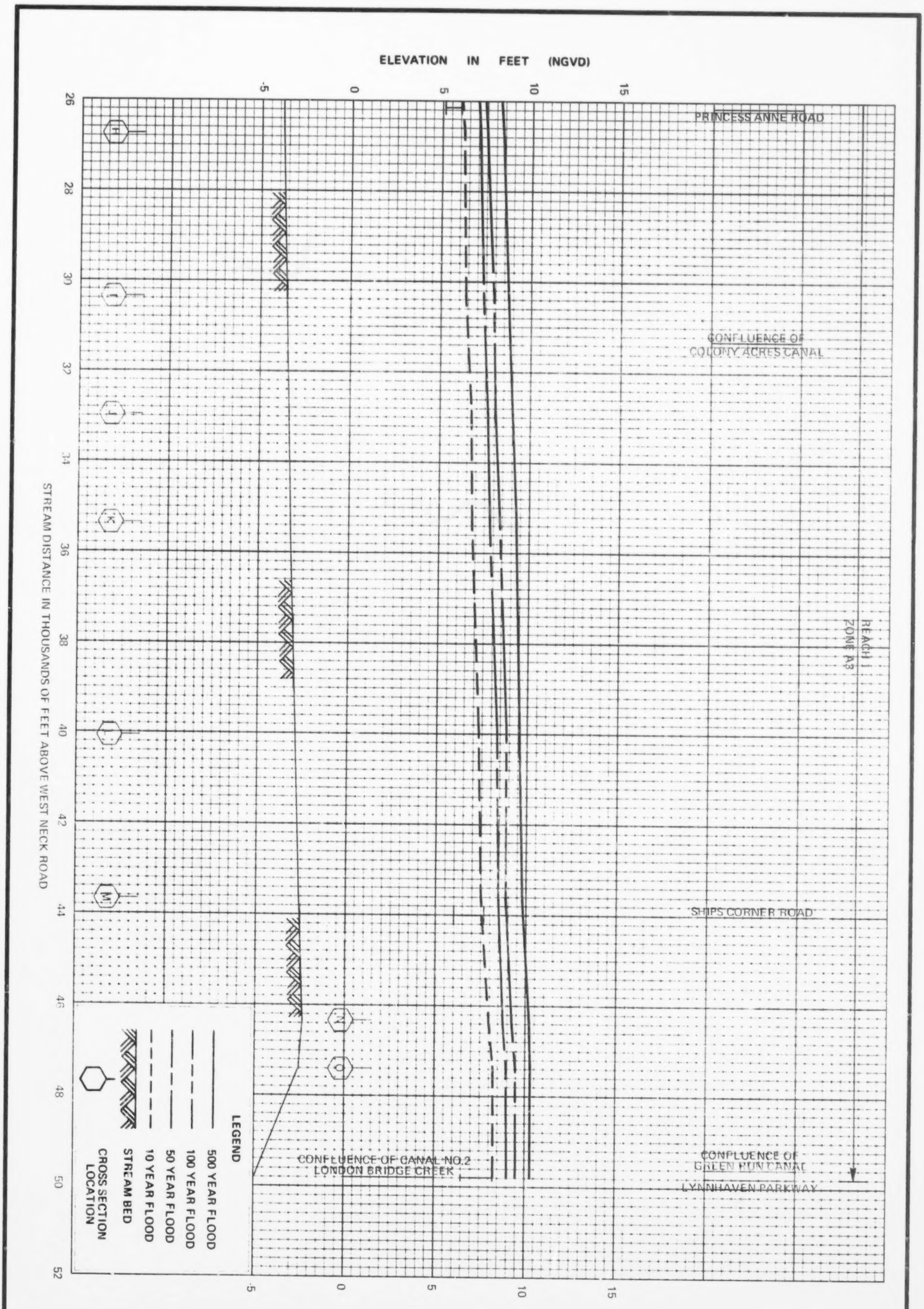
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

CANAL NO. 2- WEST NECK CREEK



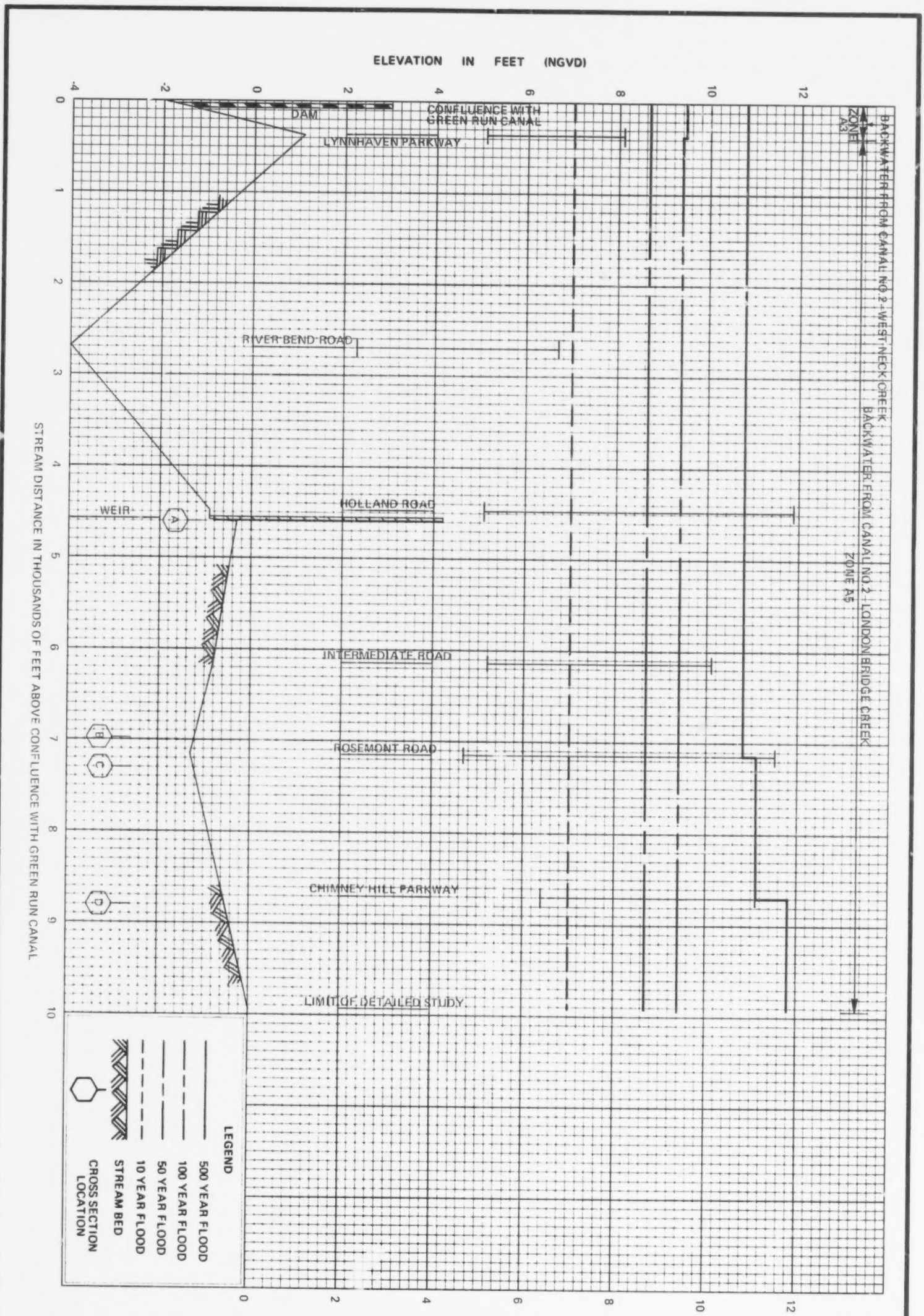
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

CANAL NO. 2-WEST NECK CREEK

12P



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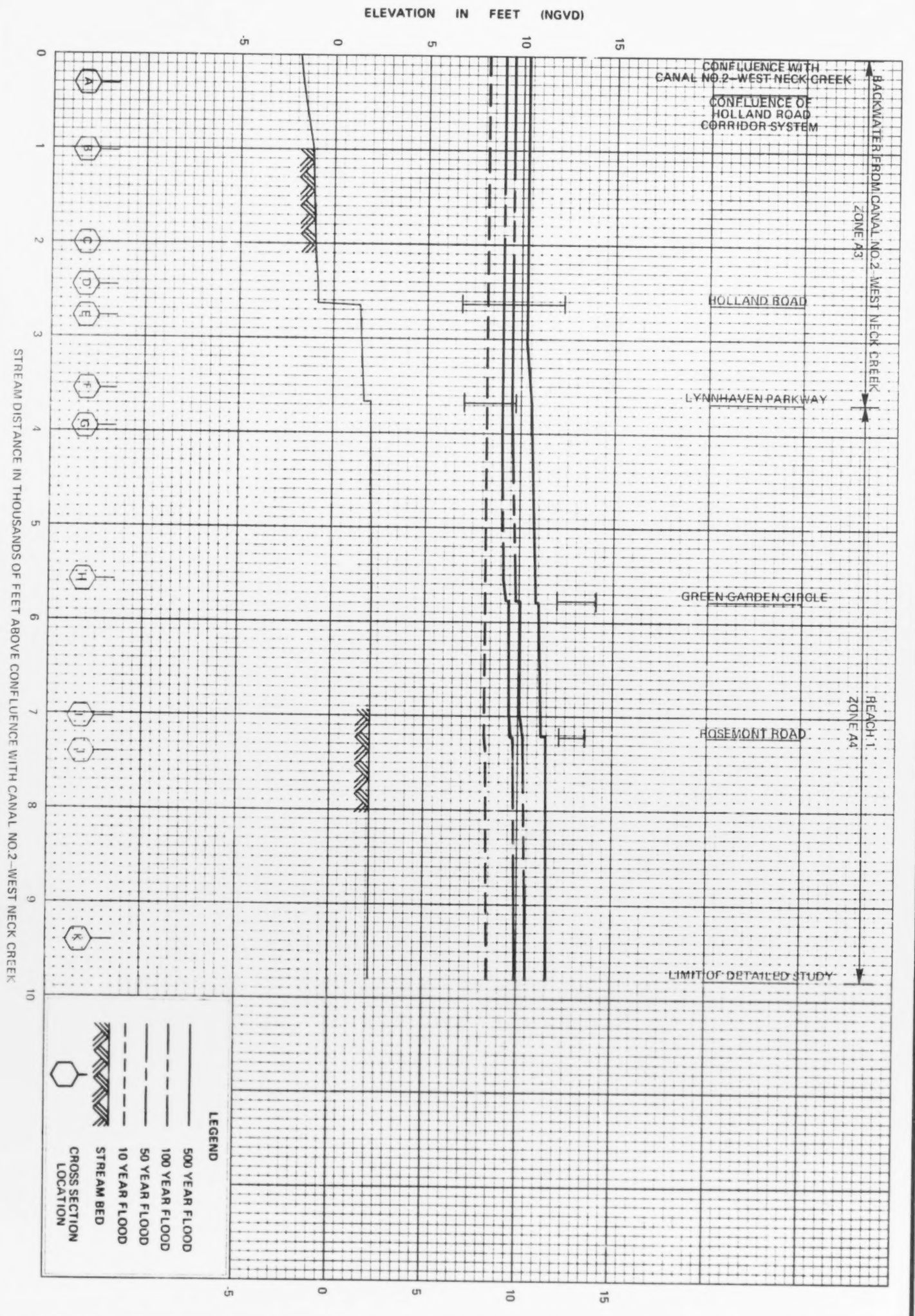
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

HOLLAND ROAD CORRIDOR SYSTEM

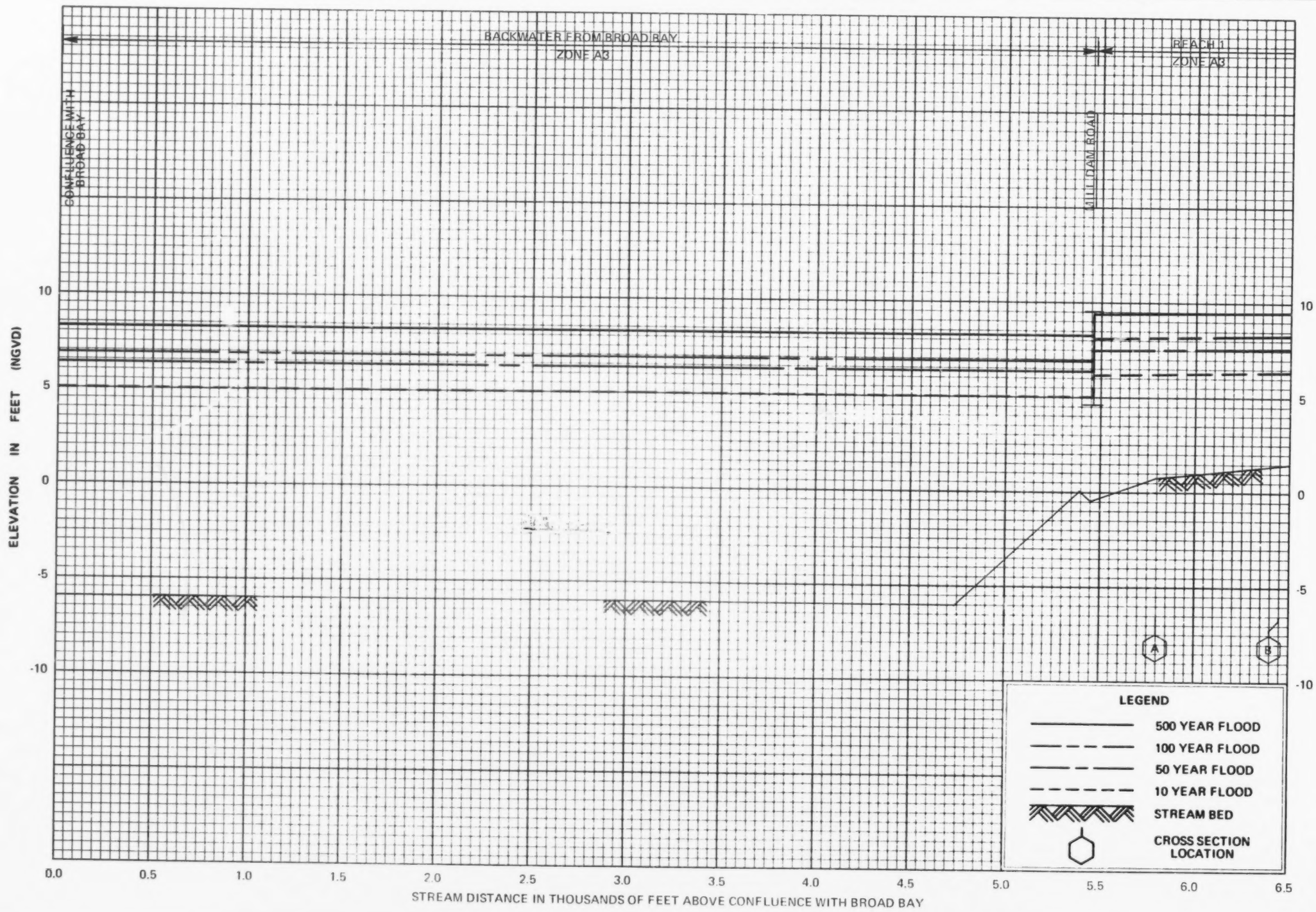


FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

GREEN RUN CANAL



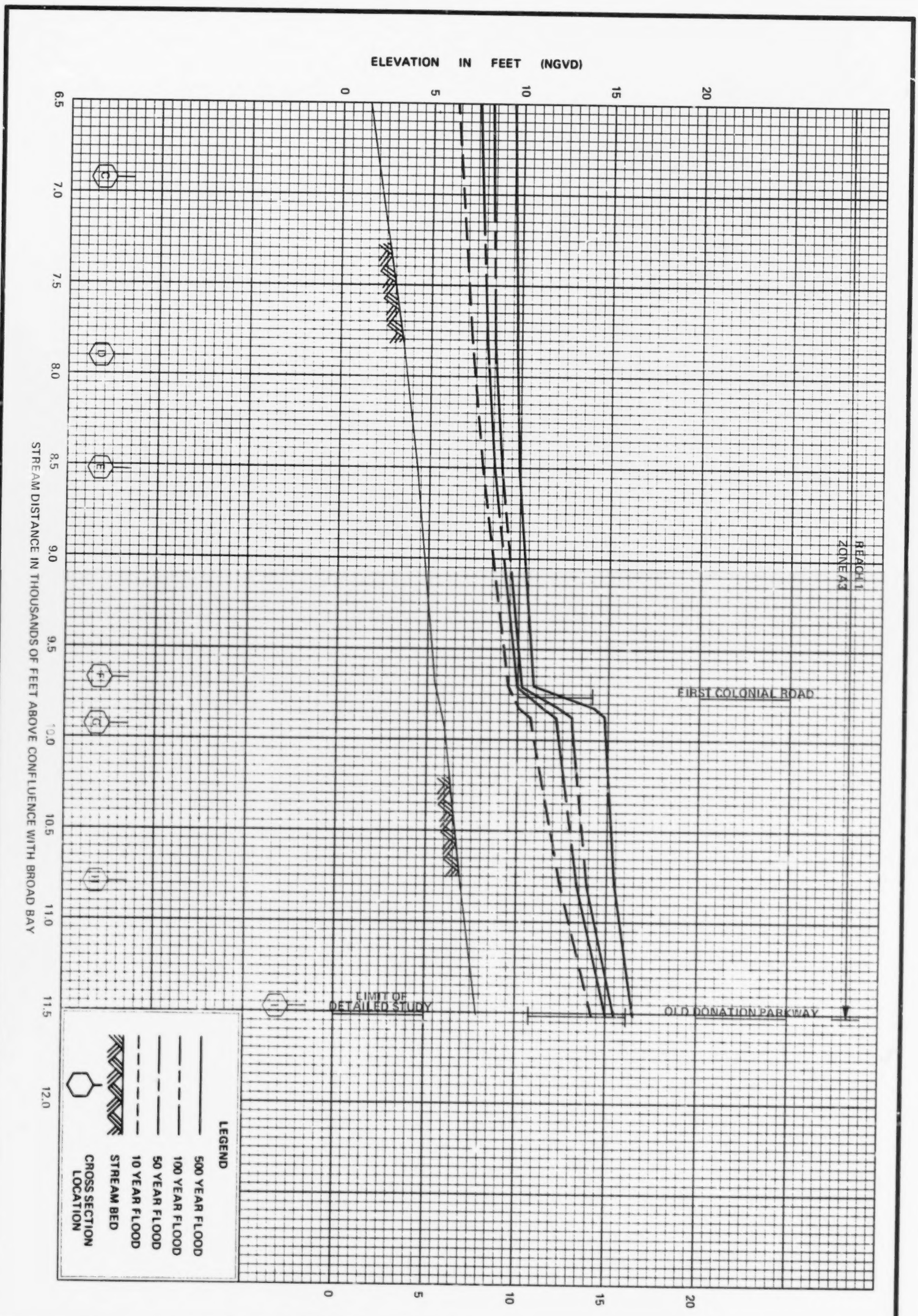
FLOOD PROFILES

MILL DAM CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

15P



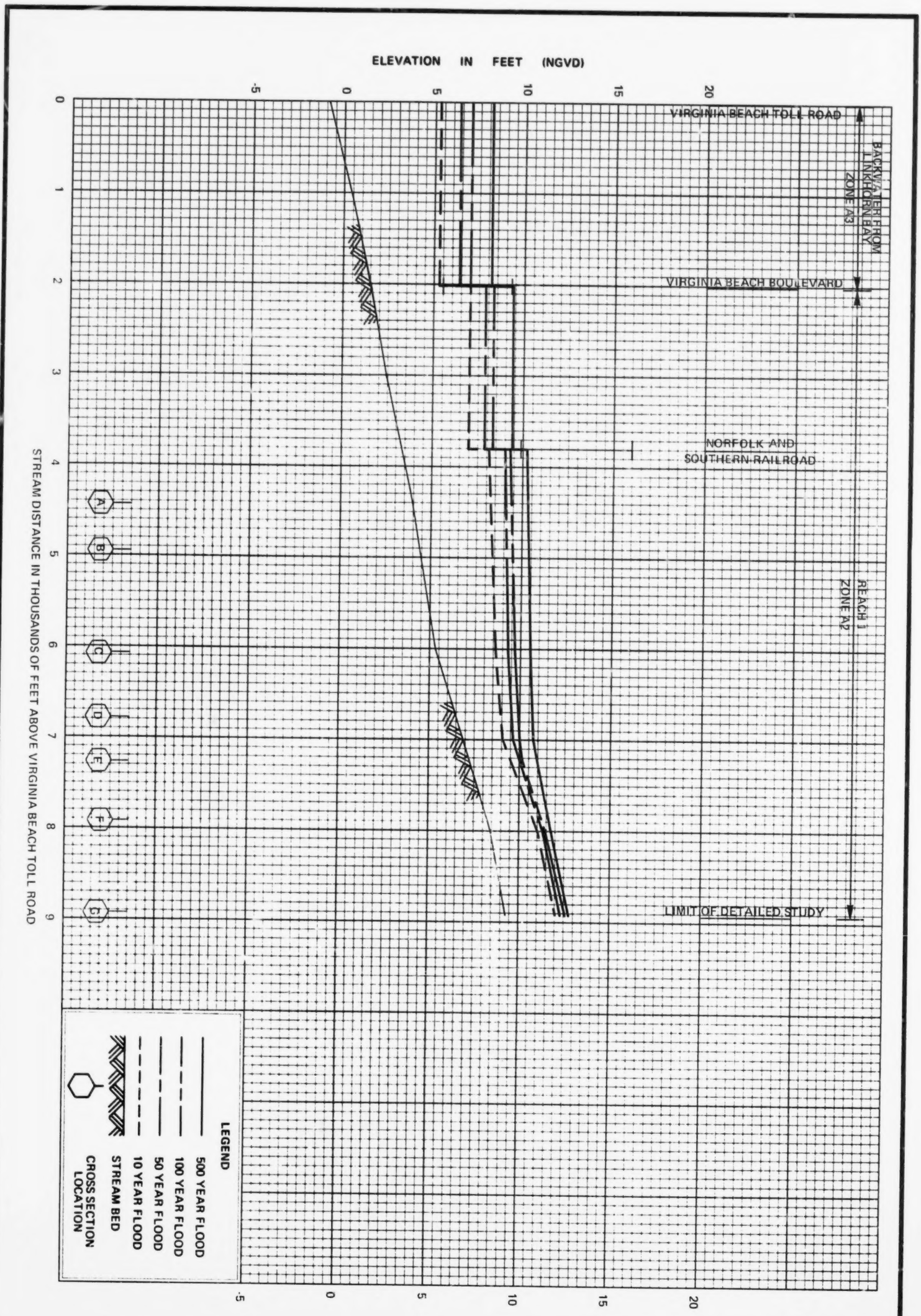
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

MILL DAM CREEK

16P



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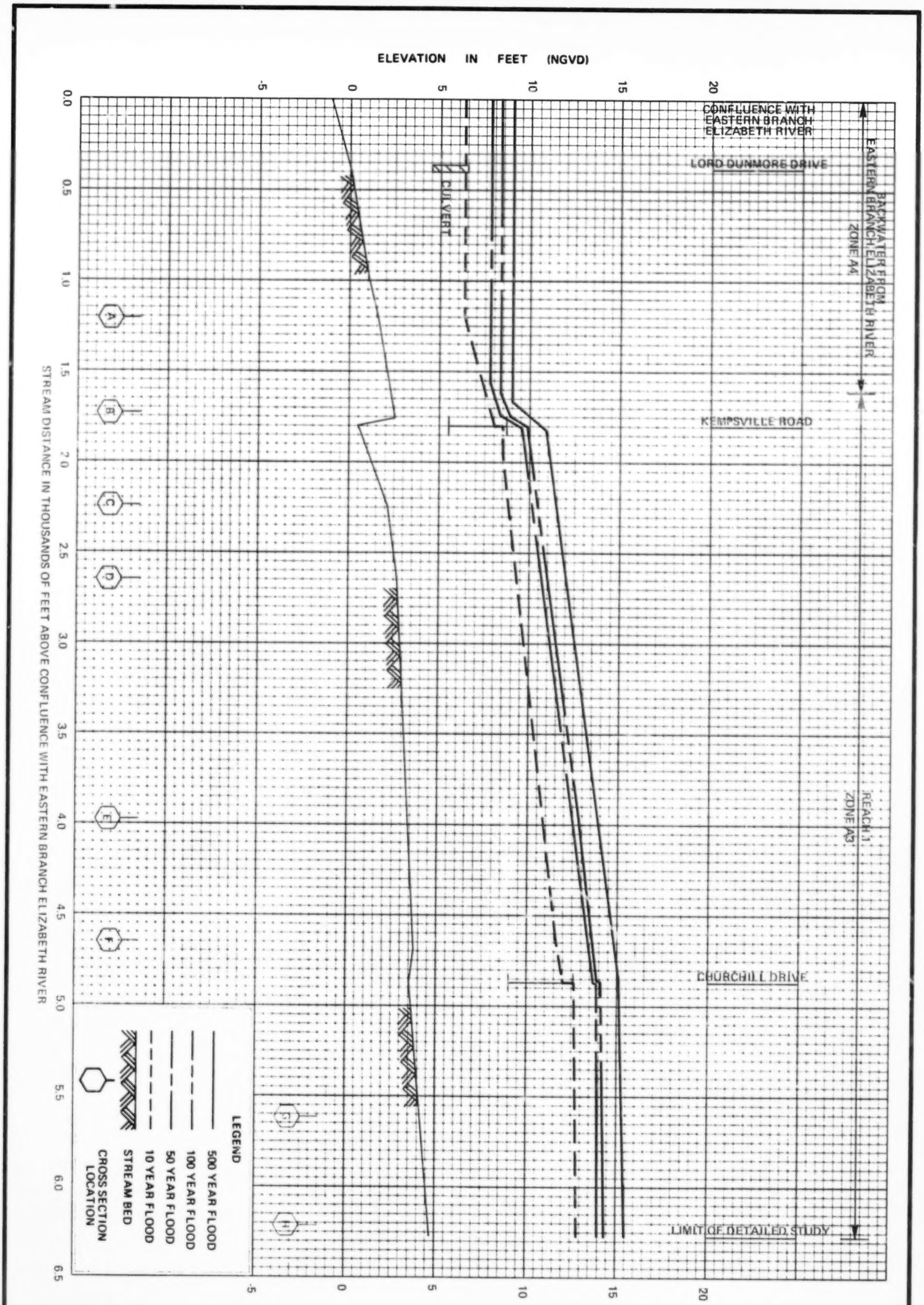
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

CANAL NO. 1 NORTH



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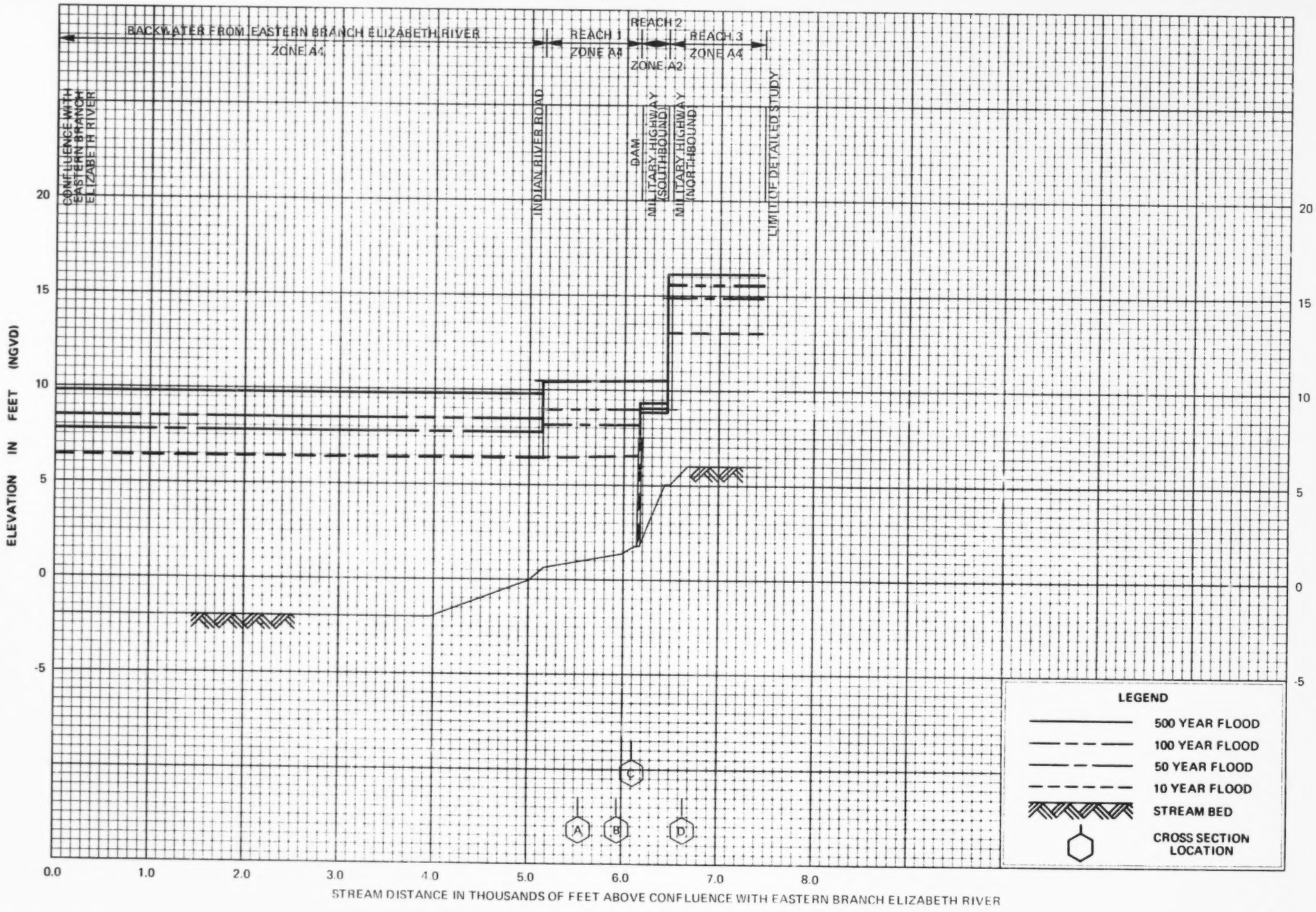
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

FOX RUN CANAL



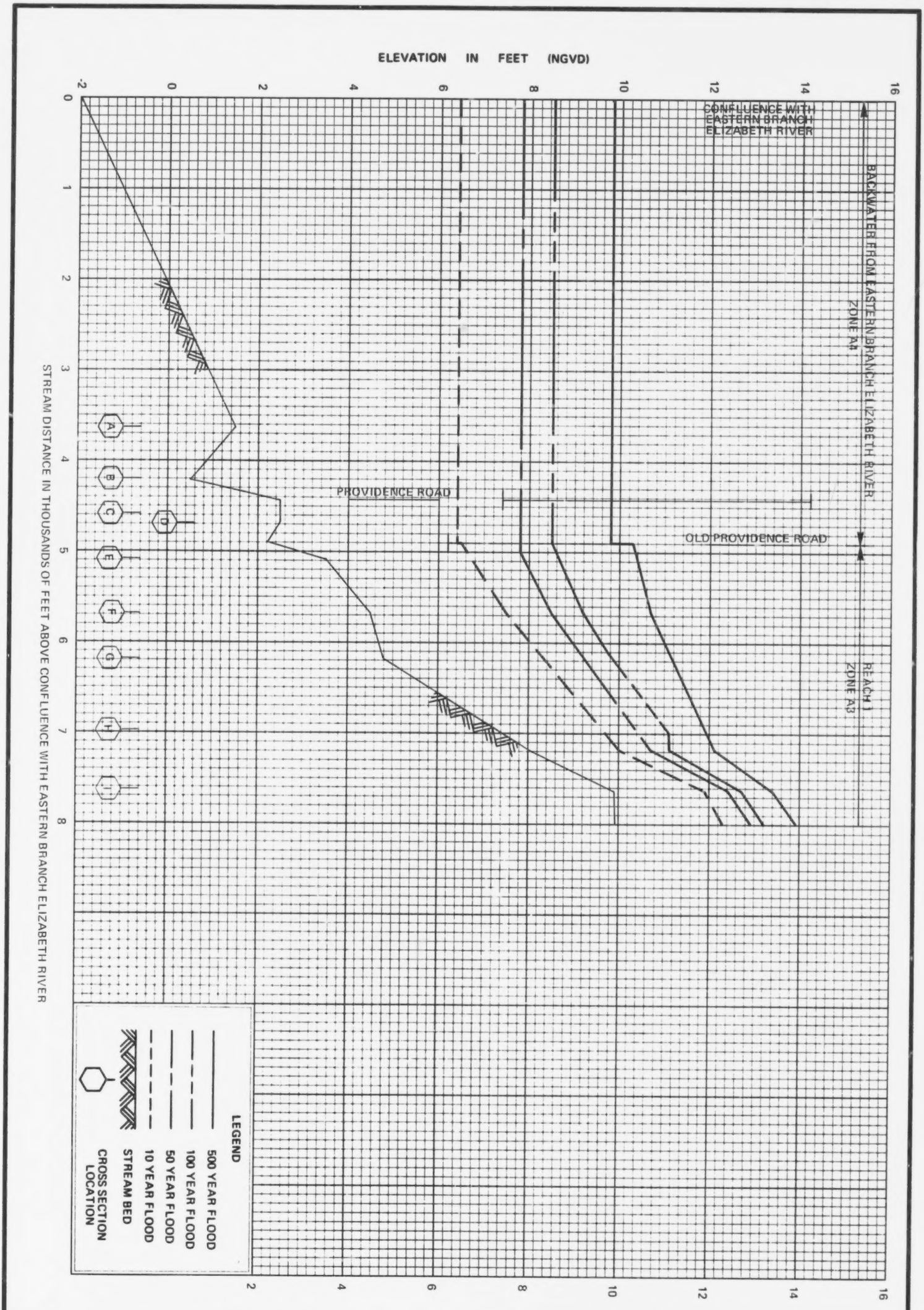
FLOOD PROFILES

LAKE BANBURY

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

19P



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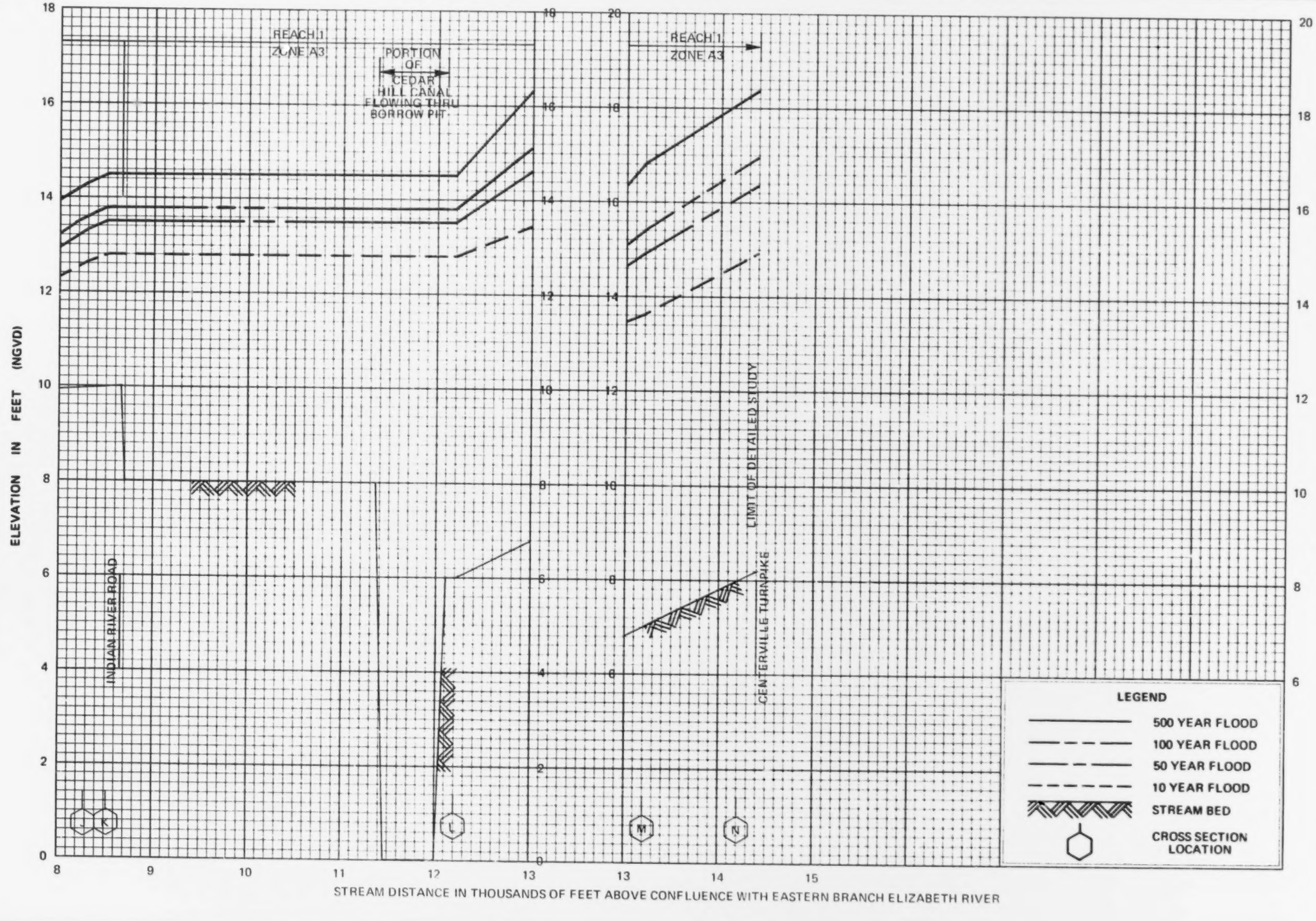
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

CEDAR HILL CANAL



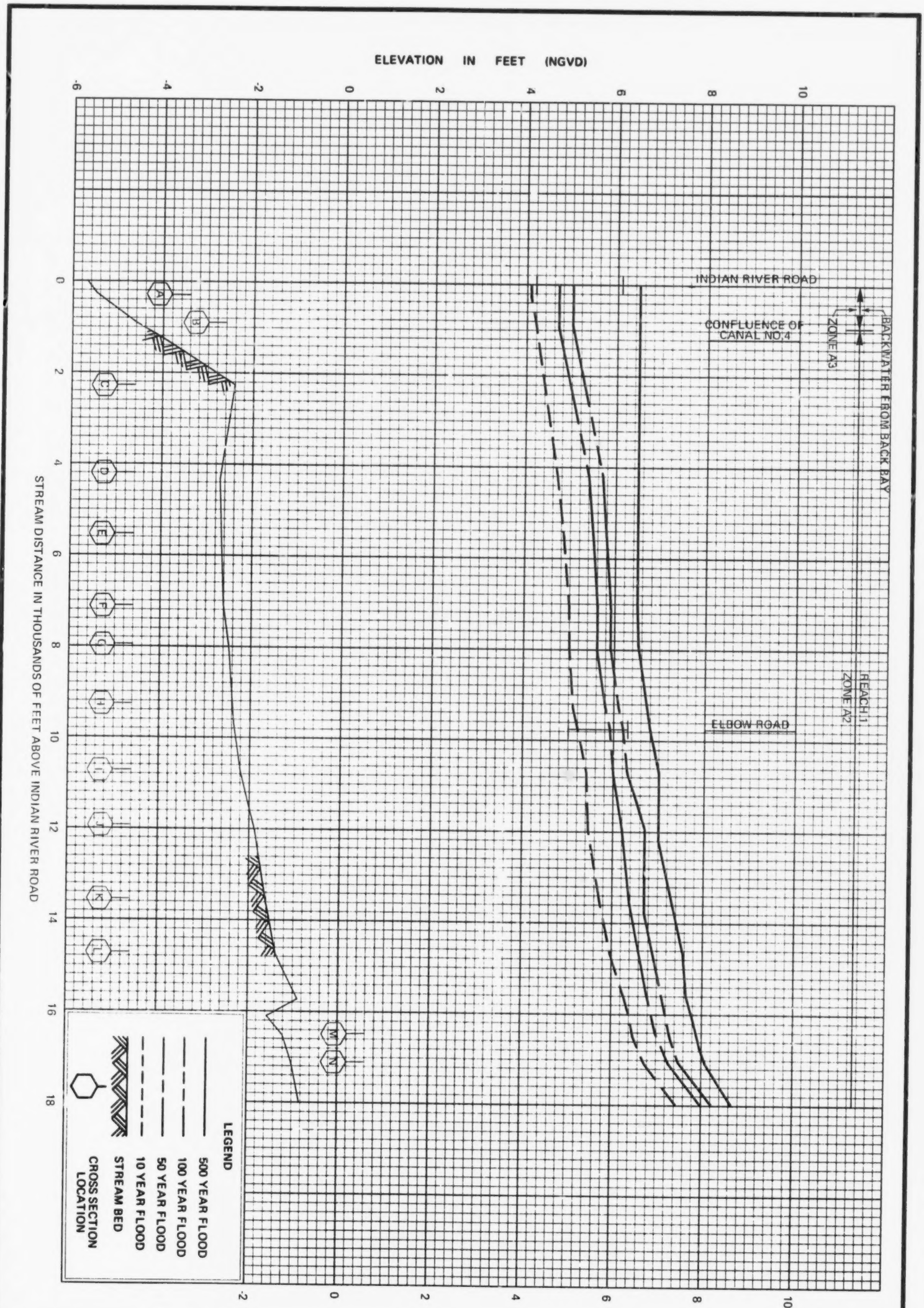
FLOOD PROFILES

CEDAR HILL CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

21P



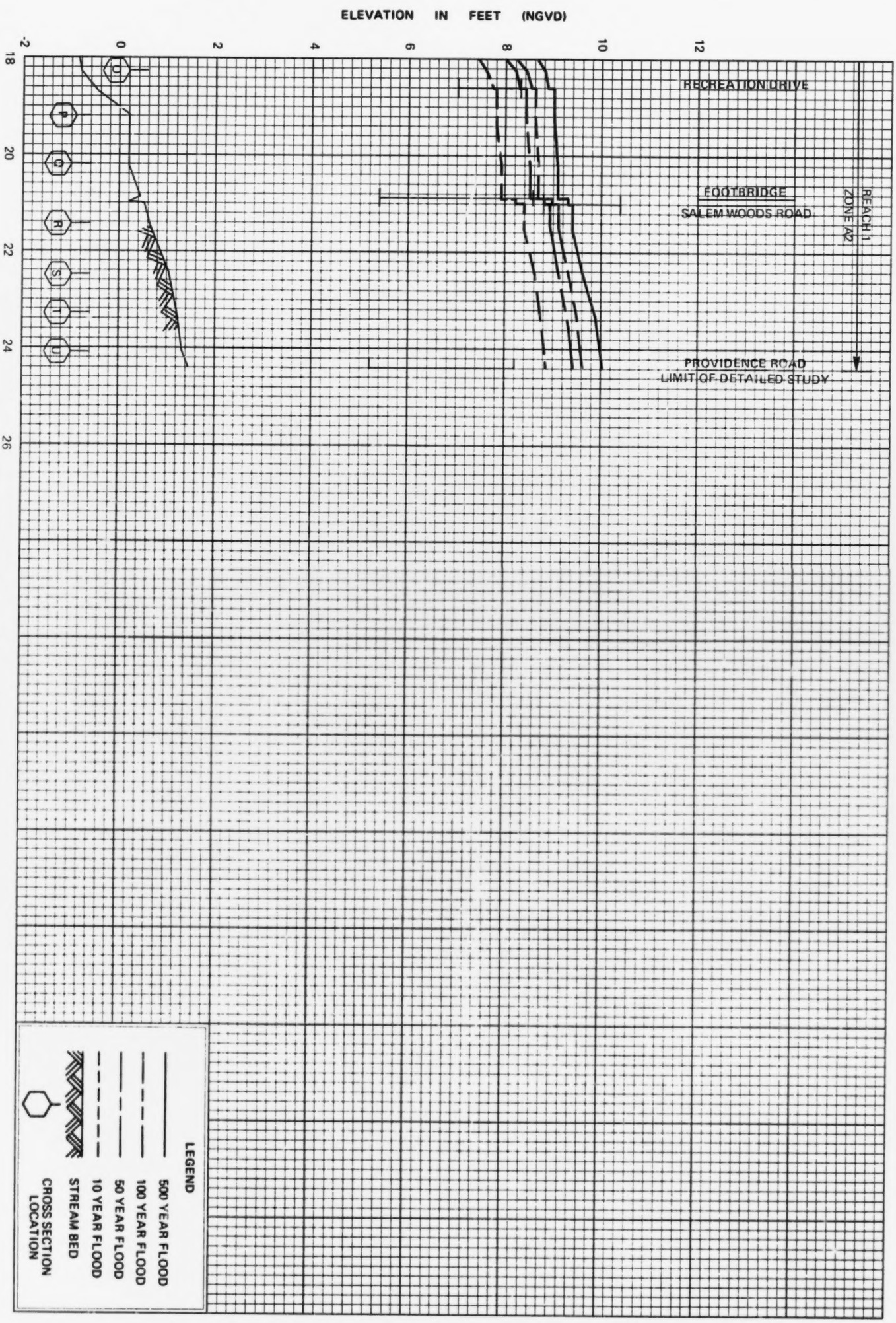
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

SALEM CANAL

22P

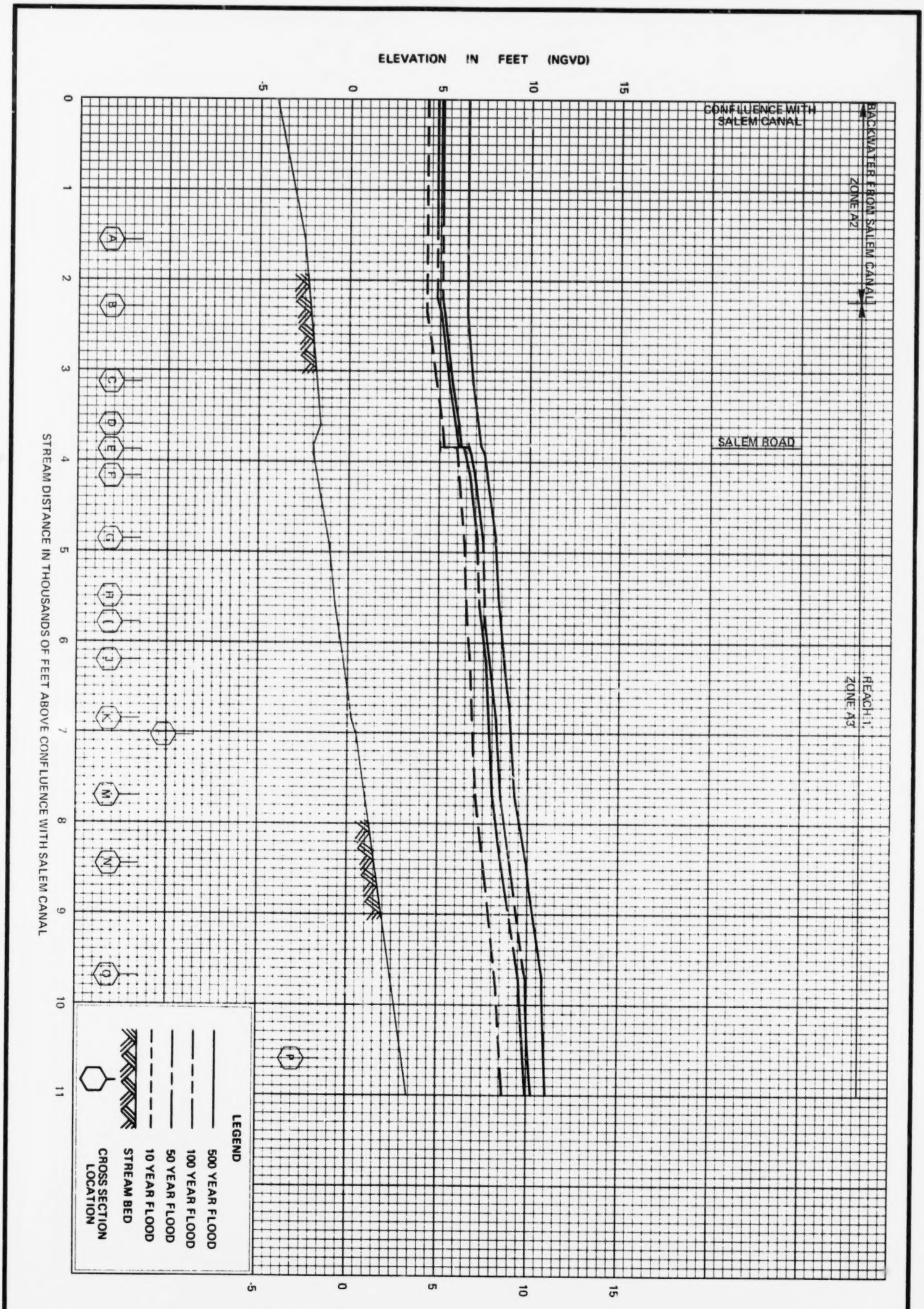


FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

SALEM CANAL



80

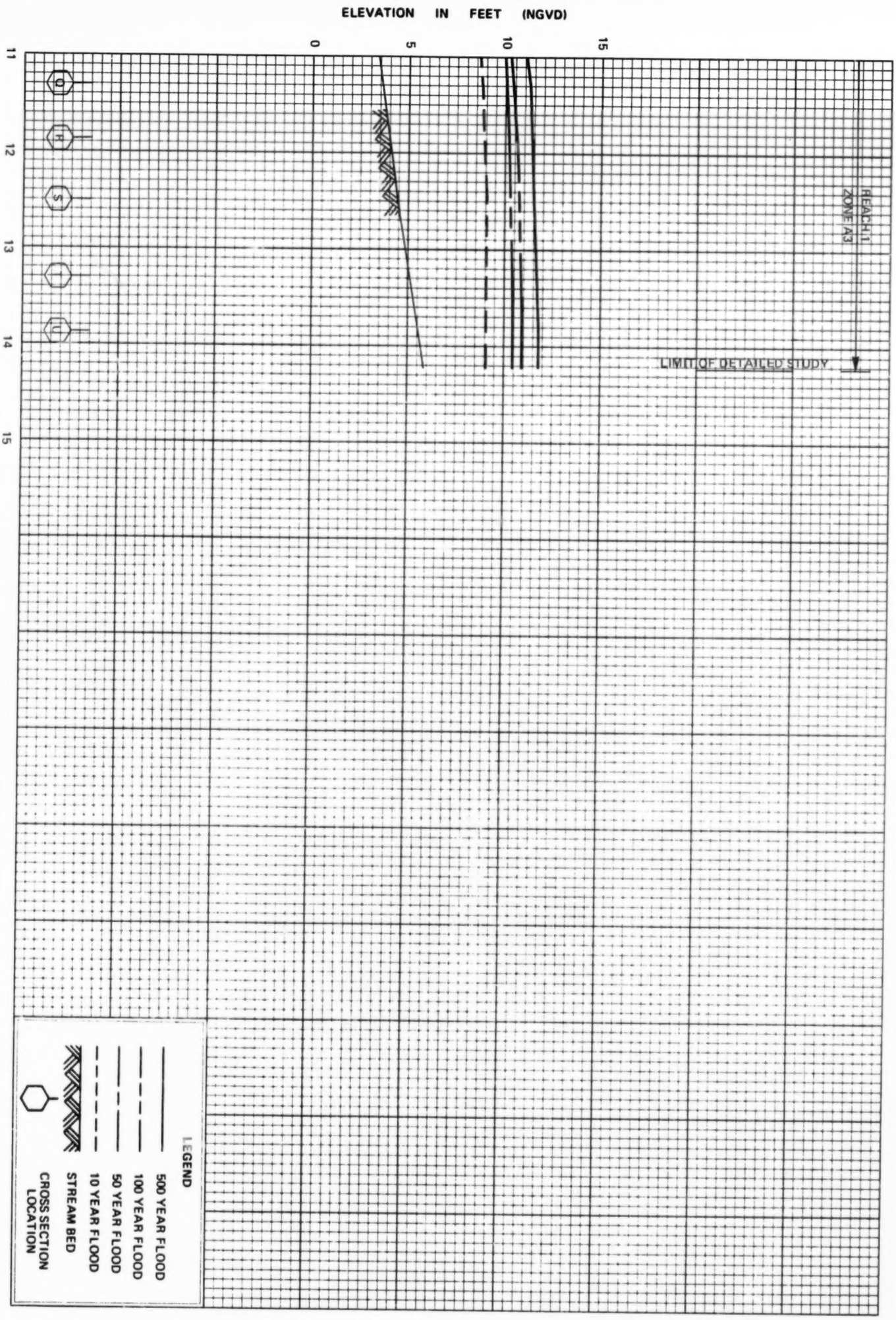
24P

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

CANAL NO. 4



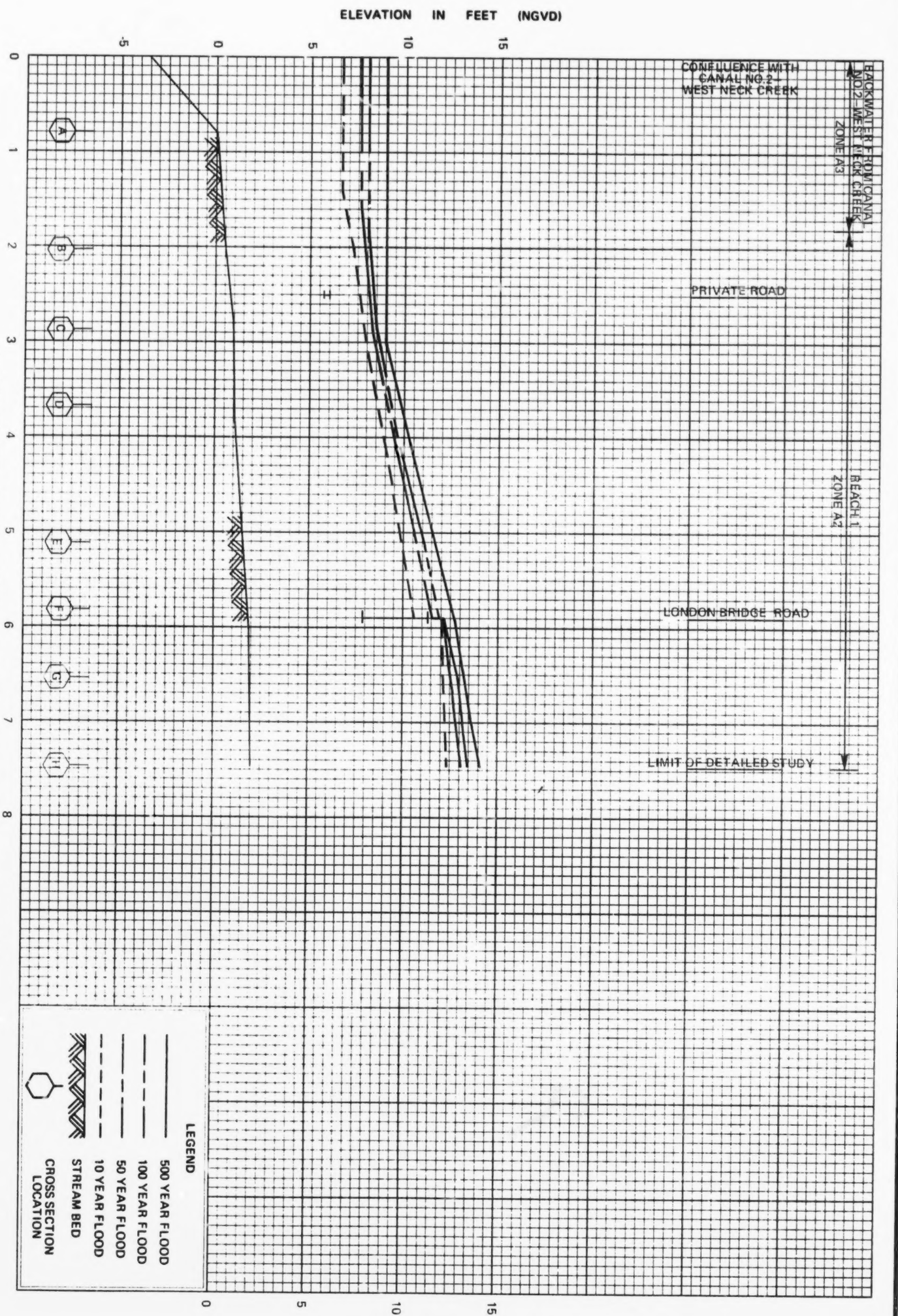
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

CANAL NO. 4

25P



FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF VIRGINIA BEACH, VA
(INDEPENDENT CITY)

FLOOD PROFILES

COLONY ACRES CANAL